DISSERTATION ON

COMPARISON OF RESULTS OF INTERLOCKING NAILING OF TIBIA WITH OR WITHOUT FIBULAR PLATING IN DISTAL THIRD BOTH BONE FRACTURES

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the regulations
for the award of the degree of

MASTER OF SURGERY (M.S)

BRANCH – II – ORTHOPAEDIC SURGERY

THANJAVUR MEDICAL COLLEGE,
THANJAVUR - 613 004.

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
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APRIL – 2017

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DR.A.BHARATHY, M.S (ORTHO), D.ORTHO, FRCS (Edin)

Professor & Head of department,

Department of Orthopaedics and Traumatology,
Thanjavur Medical College,

Thanjavur.

Dr.M.VANITHAMANI MS, Mch(CTS),

DEAN,

Thanjavur Medical College,

Thanjavur.

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Dr.S.KUMARAVEL, M.S (ORTHO), D.ORTHO, DNB (ORTHO), Ph.d ,
Professor,
Department Of Orthopaedics And Traumatology,
Thanjavur Medical College,
Thanjavur.

DECLARATION

I, **Dr.Ashok.S** , do solemnly declare, that this dissertation **"COMPARISON OF RESULTS OF INTERLOCKING NAILING OF TIBIA WITH OR WITHOUT FIBULAR PLATING IN DISTAL THIRD BOTH BONE FRACTURES"**, is a bonafide record of work done by me, in the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur, under the guidance and supervision of my Professor and Head of Department **DR.A.BHARATHY, M.S (ORTHO), D.ORTHO, FRCS (Edin) ,** between August 2014 to August 2016. This dissertation is submitted to the Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the University's regulations, for the award of M.S. Degree (Branch – II) in Orthopaedics, to be held in April 2017.

Dr. Ashok.S
Reg. No. 221412201
MS Orthopaedics,
Final Year Post graduate student,
Thanjavur Medical College,
Thanjavur.

Thanjavur Medical College

THANJAVUR, TAMILNADU, INDIA - 613001

(Affiliated to the T.N.Dr.MGR Medical University, Chennai)

INSTITUTIONAL ETHICAL COMMITTEE

CERTIFICATE

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ACKNOWLEDGEMENT

With profound gratefulness it is my privilege to thank our Dean **Dr.M.Vanithamani** who encouraged us and was kind enough to approve our dissertation.

I would like to profusely thank our Professor **Dr.Bharathy.A ,** my co-guide and our Head of the Department, who provided us with all the support , inputs and much needed advice to aid me in completing the study.

I owe my gratitude to our Professor **, Dr.M.Gulam Mohideen**, our Chief and chief-coordinator , who was instrumental in assigning the dissertation and also encouraging me to conduct the study systematic and timely manner.

I owe a deep sense of gratitude to Professor **Dr.S.Kumaravel** , my guide for this dissertation and chief , who was instrumental in brainstorming the dissertation , scientific analysis, scholarly advice and completing it successfully after meticulous scrutiny.

I would like to sincerely thank my assistant Professors **Dr.G.A.Rajmohan , Dr.D.Thirumalaipandiyan, Dr.A.Sivasenthil, Dr.M.C.Chinnadurai , Dr.K.Senthil Kumar , Dr.C.Balaji and Dr.T.Aravinth ,** under whose guidance I completed my study successfully. I would like to thank them again for sharing their knowledge and experience in each of the cases which were done under their expert guidance.

I owe a lot to my senior Post Graduates **Dr.Sudharsan.A and Dr.Siva.E** in providing valuable assistance in conducting the study in successful manner.

I thank my colleagues **Dr.P.Manikandan , Dr.T.Saminathan , Dr.Pavithra and Dr.Sajjan Soni** for providing their sincere support in my study period.

I also thank my junior post graduates in helping with and sharing all the arduous work put into the study.

I would like to sincerely thank our theatre staff members for providing their unflinching support for my study.

Last but not the least I would like to thank my parents, my sister and my fiancée for their valuable support during my entire study period.

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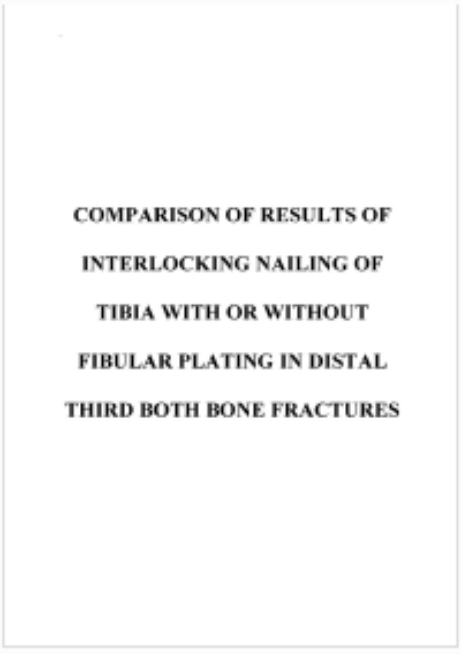

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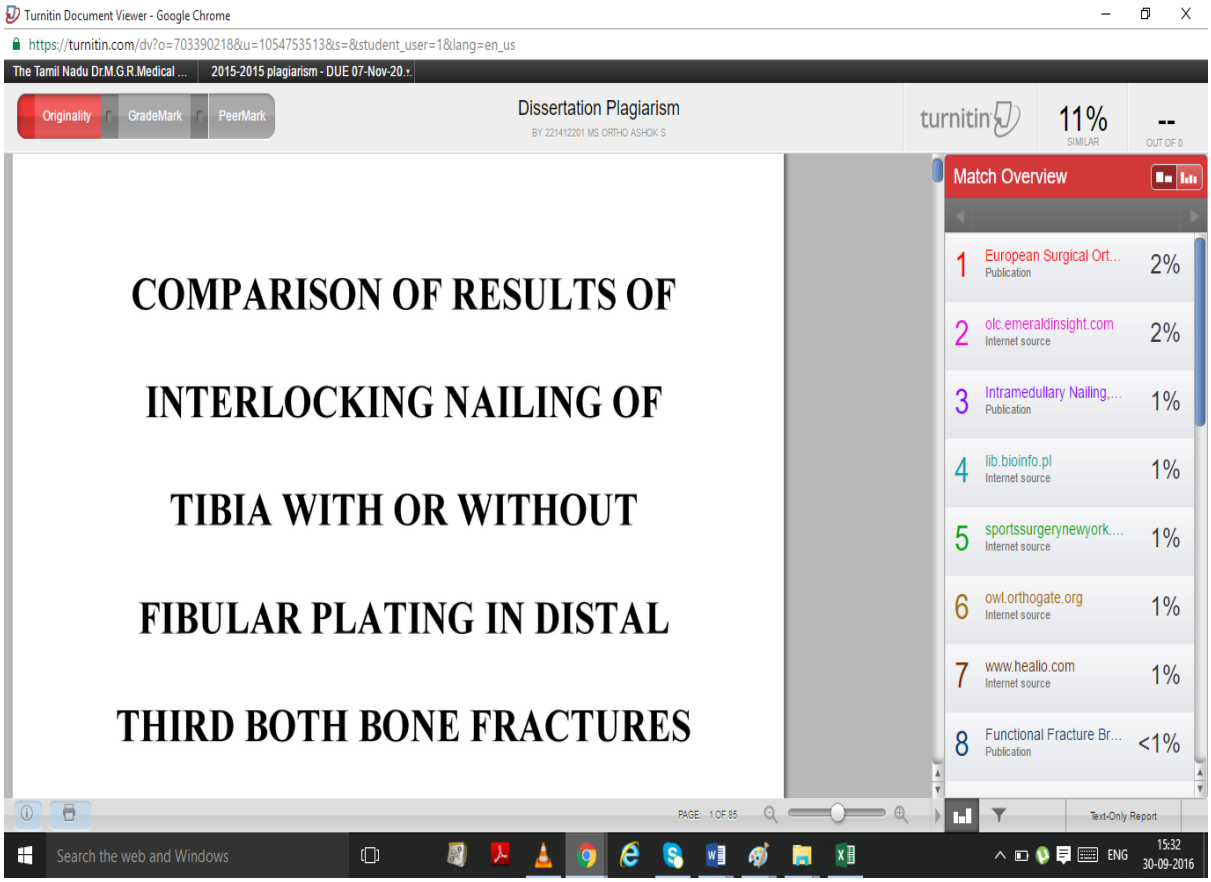
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SYNOPSIS

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ABSTRACT

A prospective case control study of 25 patients was done in 2 groups – one group was treated with fibular plating followed by interlocking nail while the other group was treated with interlocking nail only . All these cases were followed up till union. In the radiological assessment , the patients who were treated with fibular plating also alongside tibia nailing had better valgus correction.

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1. INTRODUCTION

Mass shift of rural labour from agriculture to urban area for industries and consequential rapid urbanisation has caused the injuries , especially to the leg, to be a common occurrence . Since the year 1980 , in India the number vehicles on the road has increased by several times. About 70% of them are two wheelers[1] . Injuries to the leg also occur due to mining accidents, accidental fall from height and other activities like power lifting. Correct methods of rehabilitation are required to put these patients back to the daily activities to enable them to earn their livelihood. There are lot of factors which are not in control of the treating doctor like fracture comminution, contamination , initial soft tissue injury and so forth. When such injuries are presenting themselves to the orthopaedic surgeon, the two main issues are assessing the injury and treating the same.

The common deformity of fractures in the distal leg of both bone fractures is valgus as seen in this figure **[Fig-1.1]**. This is mainly due to the mass difference between tibia and fibula. Biomechanically when the load goes to both bones, the fibula bears the stress in a less resisted manner than the tibia and hence the direction of force tend to push the distal fragments of both bones into valgus. The relative position of fibula is postero-lateral in the upper third and middle third of the leg but comes to lie in a more lateral position in the lower leg.

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Figure-1.1 – Valgus deformity in distal leg fractures

The treatment of such fractures can either be operative or conservative. Conservative treatment depends on the stability of the fracture after reduction. This requires the fracture to not to have comminution or obliqueness in shape and very severe soft tissue injury. In case the patient has severe comminution, an unstable oblique fracture or severe soft tissue injury, such fractures will not have both hard tissue and soft tissue support. Hence such injuries are better treated by operative means.

The evolution of internal fixation devices has revolutionised the treatment of tibial shaft fractures. Different techniques like locking plating after open reduction, locking plating in sliding method (minimally invasive method – MIPO), intramedullary nailing and interlocking nailing are nowadays available. The disadvantage of plating in tibial fracture setting is mainly the stripping of soft tissue like periosteum to place the plate followed by difficulty in surgical wound closure. In both these aspects intramedullary nailing appears to be a better option than plating in tibial shaft fracture treatment.

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Figure-1.2 Zone of tibia requiring nailing

Considering the indications of nailing in tibia the main factors are

1) Absence of longitudinal fractures in metaphyses

2) Adequate medullary canal diameter and

3) Length of tibia well within the lengths of the implant commonly available with the surgeon to provide adequate working length and to control the fracture fragments as seen in the figure **[Fig-1.2]**

In displaced deformed fractures, if closed reduction could correct and maintain the deformity by simple traction and plaster application, they can be managed conservatively. Other fractures need operative fixation. After either a closed or an open reduction an intramedullary nail is expected to fill the medullary canal and re-establish the longitudinal alignment of the tibia to

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near pre-injury level. The cylindrical nature of medullary canal with uniform diameter will not prevent the wobbling of the distal fragment. In such cases to avoid such problems in the past, poller screws were used on the concave side of the smaller fragment so as the nail comes into the rest of the medullary canal abutting the screw **[Fig-1.3]**. Thus the correction of the valgus deformity is possible. But this involves invasion into the fracture area defeating the purpose of biological fixation of the bone.

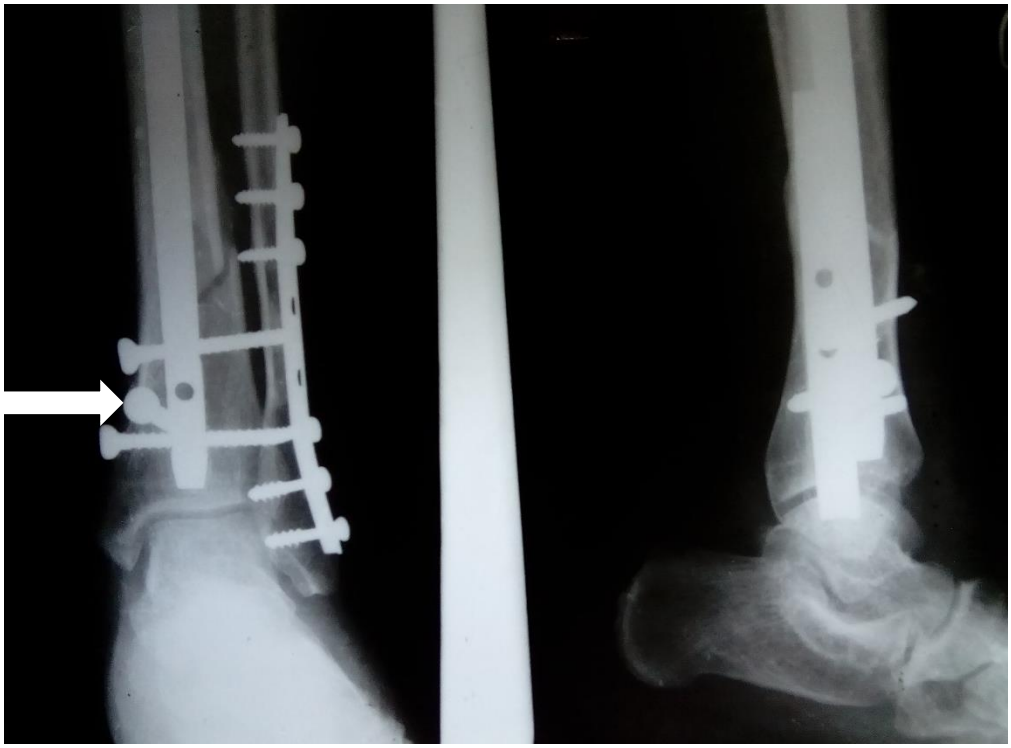

Figure 1.3 – Poller screw used in distal tibia nailing

Tibia is the main weight bearing bone and fibula assists mainly in giving length to the leg segment. Hence plating of the fibula and thereby restoring the length of the leg segment and reconstructing the lateral side architecture of the leg will indirectly align the medullary canal of the distal tibial fragment almost in line with its proximal fragment. This will facilitate the passing of an

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intramedullary tibial nail even after fibula plating, the interosseous soft tissue which is left intact will still maintain the biological hematoma of the tibial fracture. This preserves the primary hematoma of the tibial fracture. This above manoeuvre will be correcting the deformity with respect to the tibial fracture site even before the tibia is actually fixed. Compared with the tibia, the fibula has more muscle cover and nutrient arteries entering it. Hence an invasive approach to fibula fracture may not affect union of its fracture. There are studies which advocate

1) Isolated nailing of tibia [2,3,4]
2) Open plating of fibula followed by closed nailing of tibia[5,6,7,8,9,10,11]
3) Applying Poller's screw to position the nail.[12,13]

There are also articles like Sarmiento and Lata[14] to ignore the deformities and not go for accurate reduction based on the concept of soft tissue pegs detached from the bone .

There are also many studies conducted and are being conducted to evaluate the treatment options of distal leg tibia and fibula fractures.

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2. RELEVANT CLINICAL ANATOMY OF LEG AND CONCEPTS OF INTERNAL FIXATION

With respect to the anatomy of the leg in connection with our study the following aspects are to be considered.

The tibia serves as the weight bearing support of the body. The neurovascular supply of the foot with the extrinsic myotendinous units, is located throughout the lower leg.

Tibia is surrounded by soft tissues asymmetrically which in turn determine the shape of the lower leg. It is triangular in cross section, with an anteriorly directed apex and anteromedial subcutaneous surface with no muscular attachments. The palpable surface is concave medially. [15]

Anterolateral surface forms the medial wall of anterior muscular compartment containing tibialis anterior, distally the neurovascular bundle and extensor hallucis longus .

The posterior tibial surface gives attachments to Semimembranosus , Popliteus , Soleus , Tibialis posterior and Flexor digitorum longus . The posterior tibial neurovascular structures and Flexor halluces longus approach it distally curving around the medial malleolus behind the tibialis posterior and the flexor digitorum longus.

The length of an adult tibia varies between 30cm to 47cm in length on an average and a diameter of 8mm to 15mm. It is mostly diaphyseal but the

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enlarged proximal and distal ends are composed of cancellous bone, where the screw purchase is provided by cancellous bone.

Proximal tibial metaphyses is triangular, much larger than shaft, overhangs the interosseous membrane and articulates with the head of fibula posterolaterally. The patellar ligament attaches to the tibial tubercle which forms the anterior apex. There is an anterior angulation of proximal tibia of about 15^0. The backward slope of the tibial plateau, of about 6^0, provides an obvious entry point for passage of IM nail , where the cancellous bone can be perforated easily, but care should be taken not to perforate the thin posterior cortex. **[Fig 2.1]**

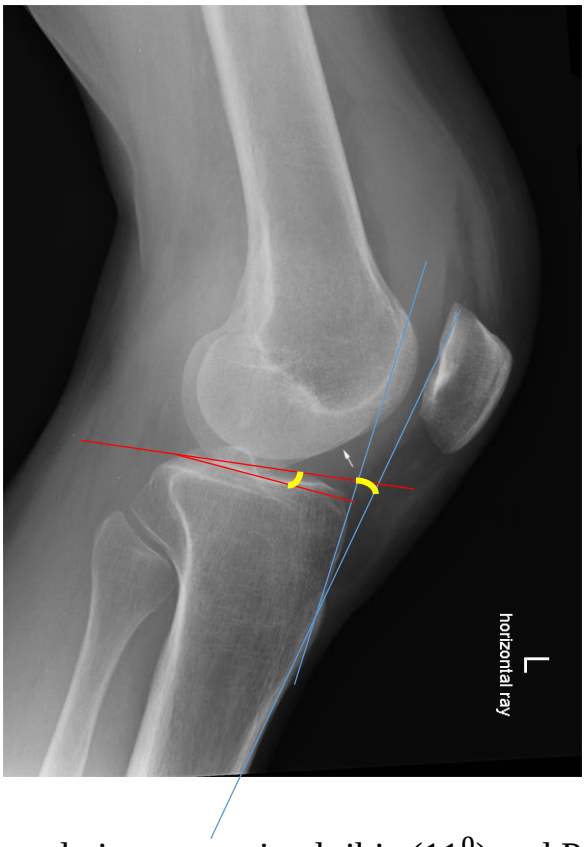

Figure 2.1 – Angulation at proximal tibia (11^0) and Posterior tibial slope angulation (6^0)

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Five to ten centimetres distal to tibial tubercle , the medullary canal becomes distinctly tubular and the walls become thick and the anterior apex forms about one third of the diameter.

The shape of the medullary canal can be regarded as a right angled triangle with medial cortex as the hypotenuse side. The medullary canal occupies the posterolateral corner of this triangle. It should be remembered that the more palpable anterior crest actually lies laterally and does not mark the midaxis and the medullary canal lies actually medial to it. This should be kept in mind while placing screws in the tibial shaft , to direct the drill a bit posteriorly in order to bisect the canal. **[Fig-2.2]**

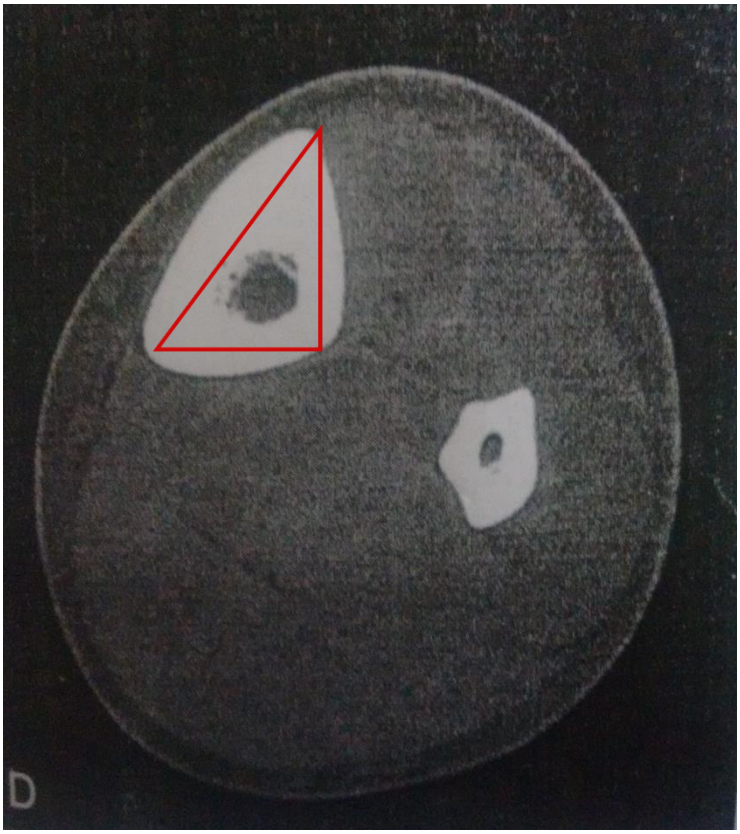

Figure 2.2 – Triangular shape of Medullary canal of tibia

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Distally the shaft becomes more rounded and flared , the cortex thins and fatty medullary canal is replaced by cancellous bone. At about 5cm proximal to the tibial plafond , the cancellous bone is so thick as to resist penetration by an intramedullary nail.

The distal tibial contour - concavity of the anteromedial surface the restoration of which is an essential part of closed reduction of fractures of distal tibia.

If the axis of the medullary canal is extended proximally it would enter point just lateral to the middle of the tibial plateau.

Unlike femur , tibial isthmus is variable and it is almost hourglass shaped.

Even after reaming one can obtain a snug fit for an IM nail only in the middle segment owing to the wide nature of the proximal and distal shafts, hence stability may be compromised. Unlike young patients ageing and osteoporosis make the canals wider and the cortices thinner , thus increasing the medullary canal diameter and further decreasing the stability of a nail fixation.

Blood supply of tibia provided by a solitary nutrient artery , proximal branch of posterior tibial artery. It courses proximally and distally anastomosing with the metaphyseal blood vessels. The medullary arterial system provides blood supply to the majority of the injured diaphysis. Only the peripheral one third / one fourth supplied by the anastomosing periosteal vessels. This is of importance in

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IM nail reaming because both the reaming and fracture produce a necrotic layer of bone. The medullary circulation takes a few weeks to regenerate. [15]

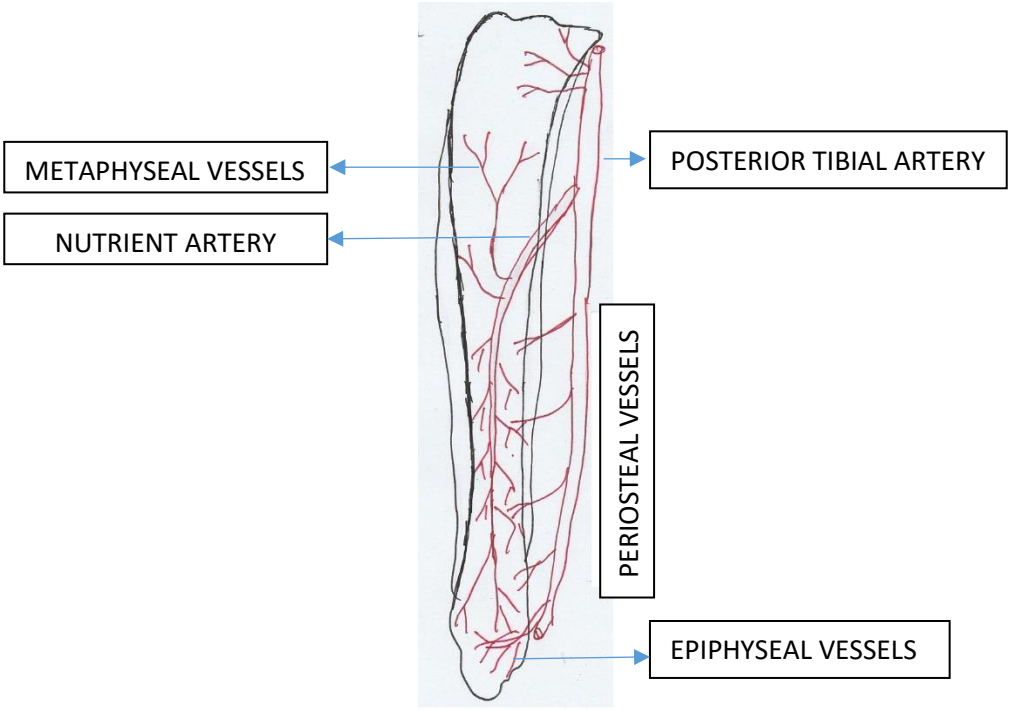

Figure 2.3 – Blood supply of tibia

The investing layer of deep fascia provides cover to all vascular structures and muscles of the leg. It goes all around the leg from the anterior border of tibia attaching finally to the medial tibial border.

The 3 compartments of the leg are

1) Anterior or extensor
2) Lateral or Peroneal
3) Posterior or flexor – subdivided into superficial and deep

The various compartments arise out of the compartmentalisation offered by

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the superficial transverse fascial septum , deep transverse fascial septum and the interosseous membrane . [16]

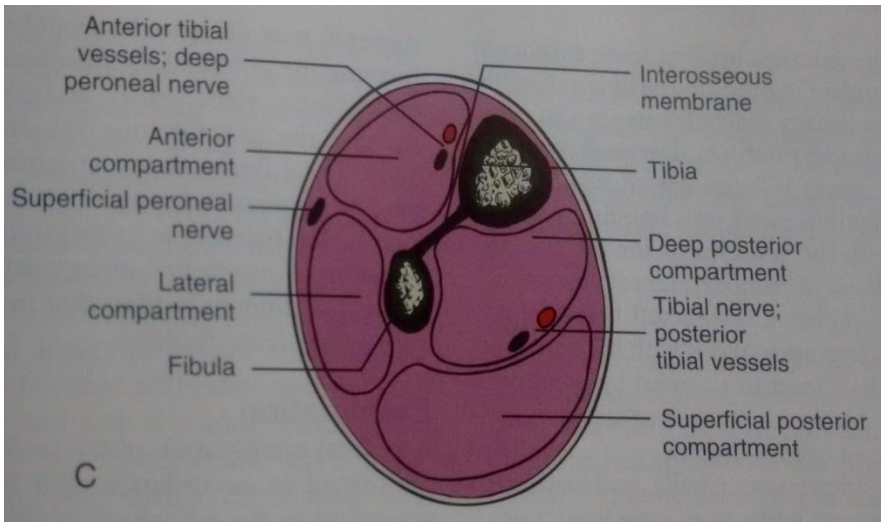

Figure 2.4 – Cross section depicting compartments of the leg

COMPARTMENT	**MUSCLES**	**NERVES AND ARTERIES**
ANTERIOR	Tibialis anterior , Extensor Hallucis longus, Extensor Digitorum Longus , Peroneus Tertius	Anterior tibial artery and Deep Peroneal Nerve
LATERAL	Peroneus longus and Peroneus Brevis	Superficial Peroneal nerve
POSTERIOR SUPERFICIAL	Gastrocnemius, Soleus, Plantaris	
POSTERIOR DEEP	Tibialis Posterior , Flexor Hallucis Longus, Flexor Digitorum Longus and Popliteus	Posterior tibial artery, Peroneal Artery and Tibial Nerve

Table 2.1 – Compartments of the leg and their contents

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POSTERIOR COMPARTMENT

The posterior compartment can be divided into 2 portions

1) Superficial – 2 heads of gastrocnemius , plantaris and soleus
2) Deep – tibialis posterior , Flexor hallucis longus and flexor digitorum longus.

The posterior tibial neurovascular structures lie in between superficial and middle groups

ANTERIOR COMPARTMENT

Tibialis anterior - upper ½ lateral surface of proximal tibia and interosseous membrane – becomes tendon middle 1/3rd of the leg , follows the anterior border of tibia and crosser over to the anterior over medial malleolus under the extensor retinaculum to be inserted into the medial cuneiform and base of 1st metatarsal

Extensor hallucis longus – lies between tibialis anterior and the extensor digitorum longus . Its origin is from middle two fourths of fibular shaft and adjoining interosseous membrane – accompanied by the extensor digitorum longus under upper extensor retinaculum , crosses the ankle joint over the anterior tibial neurovascular structures, then comes to lie medial to Dorsalis pedis artery and gets inserted into the proximal phalanx of great toe.

`

Extensor digitorum longus – takes origin from the upper 3/4th anterior fibular surface and interosseous membrane. The tendon passes behind the superior extensor retinaculum , in front of the ankle joint and then under the inferior retinaculum, then divides into four slips to insert into middle and distal phalanges of lateral four toes .

Peroneus tertius is considered a part of Extensor Digitorum Longus , inserted into the dorsum of the 5th metatarsal. The anterior tibial vessels lie medial to the deep peroneal nerve in the entire course from the proximal third where the pierce the anterior intermuscular septum pass between the Extensor digitorum longus and fibula. In the distal third when the muscles are converted into tendons they come to closer to the skin surface . The deep peroneal nerve supplies the four muscles of the anterior compartment . This deep peroneal nerve leaves the anterior compartment passing deep to anterior annular ligament and continues along with dorsalis pedis artery. The anterior tibial vessel is overlapped in the middle by the extensor hallucis longus as it crossed over and as it passes between the extensor hallucis and digitorum longus tendons it passes behind the superior extensor retinaculum leaves the ankle and continues as dorsalis pedis. [17]

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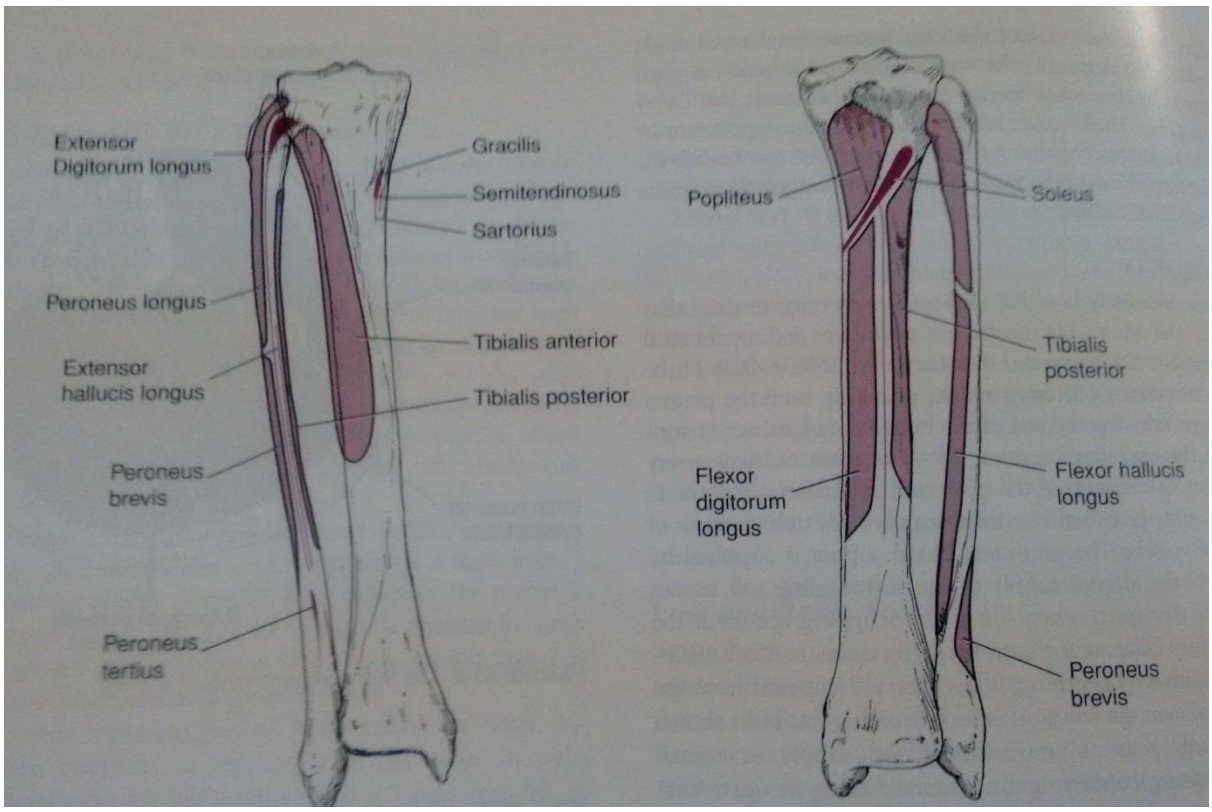

ANTERIOR **POSTERIOR**

Figure 2.5 – Muscles of the leg and their origins

THE DISTAL TIBIAL FRACTURES

Focussing on the distal third fractures of the tibia , due to soft tissue complications they pose much difficulty in management.

Options to treat distal third fractures are many. Emergent management includes icing , splinting , limb elevation and external fixator application till the soft tissue injuries heal . Non operative management is advised in undisplaced fractures and patients with high surgical risk . Long leg cast with 30 degree knee flexion for 3 to 4 weeks followed by short leg cast 6 weeks. In displaced fractures

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, 6 weeks long leg cast after closed reduction then switched over to a PTB (Patellar tendon bearing) cast. Non weight bearing advised till radiological signs of union as prone to displace on weight bearing. [18]

Considering the surgical management – options are either an intramedullary nail or a locking plate for tibia , with optional fibular fixation. Fibular fixation has been associated with contradicting results as in some studies where it is suggested that its useful to prevent any late malalignment and in other studies where it is reported to increase chance of non union as it leads to decreased strain across the tibial fracture site. [15]

The tibial shaft changes triangular structure with an anterior apex in the middle shaft to a rounded structure in the distal shaft on cross section with a curved anteromedial surface.

The vascular supply for the middle and distal parts of tibia is provided by anterior and posterior tibial vessels upto 1/3rd of the outer cortex and the remainder by interosseous blood vessels.

Narrowing of tibia at upper two third and lower third junction makes it a common site or a fracture and union is compromised due to less than adequate blood flow the reasons being , 1) injury to the nutrient artery that enters proximally and 2) distal tibia devoid of any muscle attachments.

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The saphenous nerve and the great saphenous vein traverse from the posterior to the anterior after intersection about 10cm above the tip of medial malleolus and come across the anterior tibial cortex about 3cm.

Fibula lies parallel to the tibial shaft and posterolateral to it. Superficial peroneal nerve emerges from the posterior through the crural fascia and comes to the anterior aspect at about 11.6 cm from the tip of lateral malleolus. Syndesmotic ligaments and the interosseous membrane offer stability at the distal tibiofibular joint , which aid in achieving and maintaining tibial fracture alignment after rigid fixation of fibular fracture. [15]

CONSERVATIVE MANAGEMENT OF DISTAL LEG FRACTURES

Distal third fractures of the leg are very much amenable to conservative management but the choice of cases was limited to patients with isolated axial instability and less than 15 mm initial shortening of the limb.

Post reduction the accepted limits were less than 8 degree angulation in any plane and less than 12mm shortening , as any deformity of less than the above specified limits is less likely to produce osteoarthritis.

The most common sequelae post operatively in IM nailing is knee pain (48%) which is surprisingly not due to the implant itself.

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"The minimal shortening and angular deformities though to be acceptable with our current protocol are not complications but simply inconsequential deviations from the normal" [15]

Presence of fibular fracture is by itself more important than the geometry and location of the fracture and contrary to the popular misconception the bone with ample muscle cover heals faster , the explanation given for quicker fibular union is false. Above knee slab applied in flexion to prevent further shortening is also an erroneous practice as it has been proved that weight bearing does not produce further shortening. Faster fibular union , leads to a less favourable condition for tibia union leading to varus deformity on weight bearing , which is similar to outcome in fractures of tibia in the distal third with an intact fibula .

The determining factor for the final angulation of the tibia is rather the pattern of the tibia fracture itself. In an oblique fracture of the tibia fracture line running from medial to lateral cephalad to caudad had more incidences of valgus displacement rather than a fracture running laterally to medially , due to the abutting of the distal fragment against an intact larger proximal fragment with the tethering provided by the strong interosseous ligament . [15]

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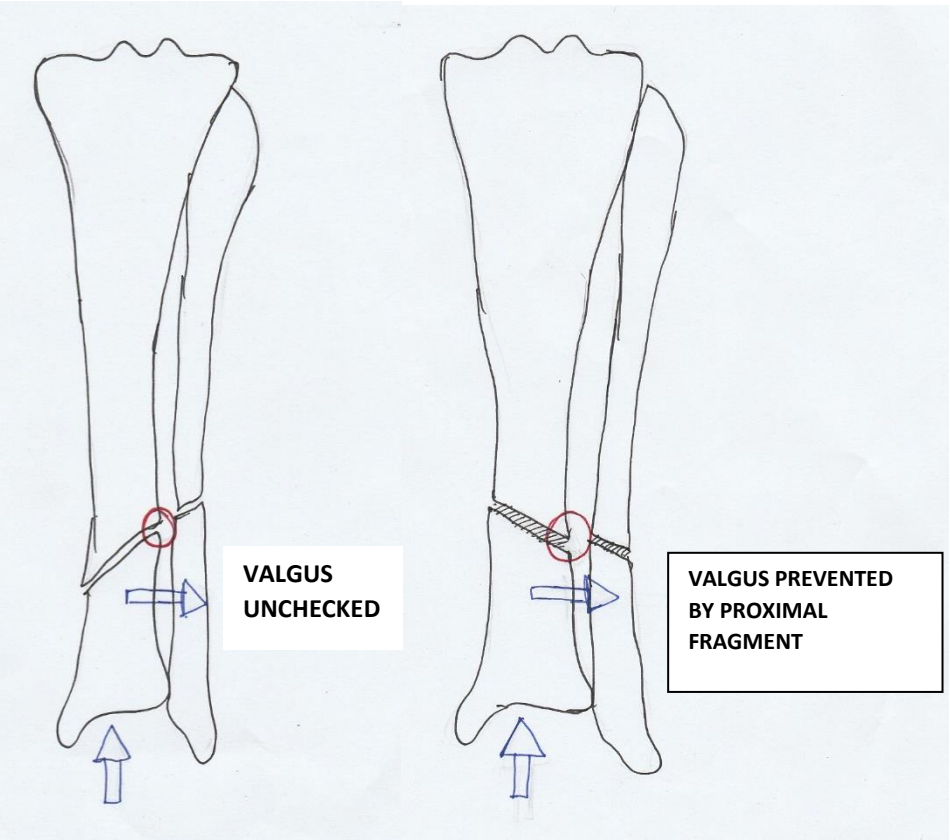

Figure 2.6 – Biomechanics of Displacement in Distal third leg fractures

As the fracture location moves more proximally chances of valgus displacement are higher due to the fact that the fibula comes to lie more posterior offering lesser restraint to lateral displacement or angulation.

SURGICAL MANAGEMENT OF DISTAL LEG FRACTURES

Established from various studies and data is that the fracture of tibial shaft is one of the most common fractures worldwide . It also has large propensity to enter into acute complications like extensive soft tissue injury , neuro vascular compromise , compartment syndromes and in rare cases fat embolism. Chronic complications that can be associated with these fractures are malunion , non union and infections. The decision on surgical management of

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these fractures depends upon the velocity of injury , soft tissue status and also the degree of deformity . Classifications like Gustilo and Anderson and Tsherne are useful in arriving at the direction of management of these fractures.

Grade 0	• Minimal soft tissue damage • indirect injury to limb (torsion) • simple fracture pattern
Grade 1	• Superficial abrasion or contusion • mild fracture pattern
Grade 2	• Deep abrasion • skin or muscle contusion • severe fracture pattern • direct trauma to limb
Grade 3	• Extensive skin contusion or crush injury • severe damage to underlying muscle • compartment syndrome • subcutaneous avulsion

Table 2.2 -- Tscherne Classification for Closed fractures

Grade	Features
I	Clean wound of less than 1cm length
II	Wound >1cm without significant soft tissue injury
III	Wound with extensive soft tissue damage; usually longer than 5cm
IIIA	Adequate periosteal cover
IIIB	Significant Periosteal Stripping
IIIC	Vascular repair required for revascularisation

Table 2.3 – Gustilo and Andersen Classification of open fractures

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Acceptable malalignment of tibial fractures according to less than 5 degrees of malalignment in varus / valgus plane 5 to 10 degrees of anteroposterior angulation rotation of less than 10 degrees and no more than 10-12 mm of shortening [18]. Decision on conservative management is not without controversy as many authors have not been able to reproduce the results given by Sarmiento and Latta by conservative management of the distal third fractures by functional bracing. It is justified to state that the acceptable length gained by manipulation and traction given initially during cast application will not have a bearing in the end when the initial shortening deformity return in axially unstable fractures with unacceptable shortening. In another study of closed treatment versus surgical management (nailing / plating) , they have reported non union rates upto 13% in both the groups, but the clinching factor being the time to solid union was far higher in the conservative group. [19]

Parameter	**Acceptable malalignment**
Valgus	< 5 degrees
Varus	< 5 degrees
Apex anterior and posterior angulation	< 5-10 degrees
Rotation	< 0-10 degrees
Shortening	< 10- 12mm

Table 2.4 – Acceptable malalignment in adult tibial fractures [18]

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Due consideration is to be given to the fact that the chances of malalignment and malunion are high because of the wide medullary canal distally. The guide wire should be centrally placed within the medullary canal on both AP and lateral fluoroscopy projections.

Fibular plating is useful in providing alignment and length of the fractured tibia. Malreduction of fibula is to be avoided as it may lead to malalignment of tibia and varus deformity. One study has reported an increase in chance of non union to about eight times when concurrent fibular plating was done with tibia nailing and further studies in this respect are needed.

THE PRINCIPLES OF INTRAMEDULLARY NAILING

Gerard Kuntscher introduced the procedure of intramedullary nailing using a metallic implant in the 1930s and termed the procedure as elastic nailing also called radial compliance . Further evolution of intramedullary devices happened over the course and Modny and Bambara introduced the transfixion intramedullary nail in 1953.

An intramedullary nail by extending from one end to the other across the fracture site provides a form of internal splintage.

The nail provides contact with the bone at the narrow entry points the isthmus and the cancellous epiphyseal region at the other end , thereby offering

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restriction to forces causing rotations , translations and angulations at the fracture site.

The bone responds to the procedure of nailing by changes in circulation of blood , the side effects caused due to reaming of the medullary canal and the nature of bone healing. With regard to circulation both the damaged periosteal blood supply and the endosteal blood supply, regenerate around the region of the fracture around the nail . It is to be noted that the damage to the endosteal blood supply can either be caused by the injury per se, during reaming as a direct effect and also due to fat particles extruded during reaming causing thrombosis.

Reaming is utilized for the fact the it improves the contact area offered by the bone. But the side effects are

1) Destruction of endosteal blood supply

2) Fat embolism risk and

3) Increased intramedullary pressure.

The increased intramedullary pressure affects the circulation further and delays healing of the fracture. Also the regeneration of the damaged blood vessels is delayed in case of a very tight fitting nail inside the medullary canal.

Nailing is minimally invasive and spares soft tissues but wide medullary canal leads to reduced bone to nail contact and reduced intrinsic stability of the construct which in turn leads to four point of bending of the screws distally as there is inferior load sharing .

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During reduction – ensuring the guide wire is centered on the tibial plafond to prevent malreduction due to the nail itself additionally poller screws may also be used to guide the nail into the desired position.

Increasing the stability of the distal construct – multiplanar distal locking screws, two distal interlocks instead of one , and biomechanical advantage offered by bicortical screws. [15]

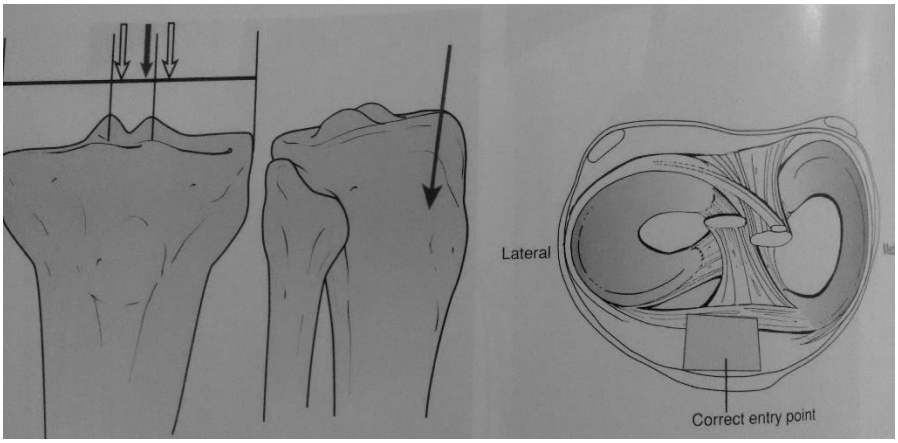

Figure 2.7 – Guideline for correct entry point of nail

The possible ways we might be able to prevent malalignment in distal leg fractures are ensuring a center to center positioning of the guide wire in the proximal medullary canal , considering placement of blocking screws in the medullary canal of distal tibia[12,13] , fracture reduction by clamping , application of a temporary external fixation and plating a distal fibular fracture which might coexist.

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Figure 2.8 – Center –Center alignment of guide wire and nail –restoration of mechanical axis

Working length of the nail is that distance across the fracture site between the distal most proximal fixation bolt and the proximal one of the distal fixation bolts

$$\text{Working length } \alpha \frac{1}{(\text{bending stiffness})2} \quad \alpha \frac{1}{\text{Torsional stiffness}}$$

So a shorter working length will offer better stability to bending and rotatory forces.

The design of the nail such that the tapering distal end will ensure that the dorsal cortex is not penetrated accidentally also the slots for the locking bolts are places such that they are away from the fracture sites.

The concept of reamed and unreamed nailing – reaming essentially is required when a larger diameter nail than the medullary canal can be inserted offering superior stability and also it provides a smooth passage while introducing the nail. Unreamed nailing indicates that there is no reaming of

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medullary canal specifically across the fracture site. These are commonly used in case of open fractures and severe soft tissue injuries.

Coming specifically to the interlocking nail ,there are two types of interlocking bolts used – the static and dynamic locking bolts. The static locking bolts confer rotational stability to the construct and also offer bridging fixation and relative stability across the fracture site.

The dynamic locking bolts locate at the extreme ends of the nail and are used alone only when there is more than 50% cortical contact between the fracture ends. 'Dynamization' denotes the procedure when the static locking bolts are removed after a considerable time has elapsed since the procedure and the healing has not progressed satisfactorily , for instance after 3 weeks in a case of tibia fracture pattern without extensive comminution.

Herzog showed that a stiff medullary nail with the cloverleaf design could also be driven into the tibia, provided the nail was bent to 11° to correspond to the anatomy of the proximal tibia and the distal end was narrowed and slightly bent anteriorly.The bends in the tibial nail are named after him. All fractures of the tibial diaphysis can be stabilized with an interlocking nailing. The thickness of the nail should be same or 0.5 mm less than that of the last reamer. As the nail is being inserted, the part of the nail with the jig still outside the canal should be forcibly pushed towards the femur so that the distal end of the nail is pushed away and does not perforate the posterior cortical wall of the upper third of the

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tibia. After the tip of the nail has passed down the canal for about 15 cm, the danger of perforation no longer exists as the nail then lying parallel to the medullary canal. The nail must advance with gentle wriggling movement. Excessive force must not be used. If the nail does not progress, either further reaming or choice of a thinner nail should be considered. [20]

A displaced fracture of the tibia requires special attention. A guide wire with a bent tip is useful to negotiate small displacements . A fully inserted reaming guide should be in the centre of the distal tibial fragment . Eccentric reaming may damage the posterior cortex with subsequent perforation of the cortex during the passage of the nail.

In a segmental fracture the intermediate fragment must be stabilized percutaneously with a pointed reduction bone forceps to prevent its rotation and inadvertent stripping of the soft tissue attachments. The nail should be long enough to perforate the transverse bone scar at the site of the former epiphyseal plate to provide additional stability . A thin (8–10 mm) solid or cannulated interlocking nail can be passed without reaming the tibial medullary cavity. Such a procedure is called ‘non-reamed nailing’ and is useful in open fractures of the tibia. However, non-reamed nailing in the presence of a severely contaminated wound or loss of bone at the fracture site is contraindicated. In the presence of a mild to moderate soft tissue injury it is a popular practice to ream the tibia up to

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10 mm and then insert a biomechanically strong nail.In the rehabilitation phase, partial weight bearing and dynamization of the construct are recommended to avoid fatigue failure of the thin nail. These measures usually lead to union.‘Exchange nailing’, i.e. removal of the thin nail, reaming of the medullary canal and insertion of a thicker nail (11–13 mm), is a viable another method and is an alternative to bone grafting in the event of delayed union and non-union.

In fractures of the upper third of the tibia, two proximal locking screws are essential. These screws prevent a small proximal fragment from moving during knee flexion. In fixation of a distal fracture a part of the nail beyond the screw holes may have to be cut so as to place the locking screws at the farthest point in the distal fragment to achieve good stability.

Figure 2.9 – Screws to be applied at the farthest point in the distal fragment

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Distal locking is always performed first. It is then easy to manipulate the locked distal fragment by moving the insertion handle. Similarly, the handle may be used to apply compression at the fracture site by reverse jamming.

Closed intramedullary nailing will prevent even the limited soft tissue damage that occurs in Minimally Invasive Plate osteosynthesis (MIPO). Also the incidences of skin necrosis are practically absent as with plating in the distal leg region.

The nail applied as either function as a load bearing device – when locked with static bolts and as a load sharing device when applied in dynamisation mode.

Also stress is laid upon achieving reduction before passing the nail unlike middle third diaphyseal fractures , because once a false track is formed in the metaphyseal region it will hinder with fracture reduction. It is in these situations that the use of poller screws or blocking screws are needed .

Evaluation of the fracture gap after passage of nail is of important. Reverse hammering might be needed if the gap is more than 3mm , else the chances of non union are more . Care to be taken to avoid malalignment in any plane.

The post-operative protocol advised, is immediate functional mobilisation of knee and ankle ; partial weight nearing depending on fracture pattern; dynamisation at about 4-6 weeks in case of persistent fracture gap , resumption of normal activities after 6-12 weeks and heavy manual labour is

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delayed upto 1 year. Implant exit if at all planned, to be done only after 1.5 years . Complications commonly encountered in tibia nailing patients are anterior knee pain , non union , infection and malunion. [21]

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3. REVIEW OF LITERATURE

A Rouhania et al , conducted a randomized prospective study on role of fibular fixation in distal third tibia and fibula diaphyseal fractures and concluded that there was neither an advantage due to fixation of fibula nor that it caused any increase of complications. [5]

Mustafa Isik et al concluded that if distal metaphyseal tibial fractures are reduced in an acceptable position and static locking is performed by placing at least 2 screws distal and proximal to the nail during intramedullary nailing, angulations in reduction that may develop during the period until union remain within the accepted reduction criteria, even if Poller screws, plate fixation of the fibula, or casting after nailing are not used. [2]

Kumar et al , in their study , were of the view that fibular plate fixation increased the initial rotational stability after distal tibial fracture compared with that provided by tibial intramedullary nailing alone. However, there was no difference in rotational structural stiffness between the specimen treated with and without plate fixation as applied torque was increased.[7]

Morin PM et al , were of the opinion that fibular plating in addition to tibial IM fixation of distal third tibia and fibula fractures leads to slightly increased resistance to torsional forces. This small improvement may not be clinically relevant.[8]

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Strauss et al, proposed at the end of their study that, in the treatment of distal metaphyseal tibia fractures, locked plates provided more stable fixation than intramedullary nails in vertical loading but were less effective in cantilever bending. An intact fibula in the presence of a distal tibia fracture improved the fracture fixation stability for both treatment methods. In fracture patterns in which the fibula cannot be effectively stabilized, locked plates offer improved mechanical stability when compared with locked intramedullary nails.[9]

Weber et al , declared at the conclusion of their biomechanical study in cadaver specimen that osteotomy of the fibula significantly increased tibial defect motion when external fixation was used, and plating the fibula in this case significantly decreased motion. Using an Enders rod to stabilize the fibula instead of a plate, with tibial external fixation, produced smaller decreases in tibial defect site motion. With IM rod fixation of the tibia, osteotomizing the fibula had no effect on defect site motion or on its subsequent stabilization using a plate or IM rod.[10]

Egol et al , opined that the proportion of fractures that lost alignment was smaller among those receiving stabilization of the fibula in conjunction with IM nailing compared with those receiving IM nailing alone. Adjunctive fibular stabilization was associated significantly with the ability to maintain fracture reduction beyond 12 weeks. At the present time, the authors recommend fibular

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plating whenever IM nailing is contemplated in the unstable distal tibia-fibular fracture. They also reported a secondary malalignment of 10%. [11]

Penzkofer et al, stated that the largest possible nail diameter should be used to minimize fracture site movement in tibia shaft fractures. ***Hoegel et al***, have shown that reamed intramedullary nails are stiffer than unreamed nails in a biomechanical testing in a distal tibia osteotomy model.[22] ***Schepers et al*** reported 17 % infection rate in locking plates against 1/3rd tubular plates for fibular fixation . ***Robinson et al*** stated that 2 different forces responsible for fractures a direct bending force which can result in a transverse type fracture and a torsional component leading to spiral or oblique type fracture. Certain investigators have reported that a concurrent plating of the fibula can aid in preventing malalignment of the distal tibia fractures. An analysis of 40 distal leg fractures. Anatomical healing occurred in five cases with intact fibulae and four fractures with fibular fixation. Among the remaining cases , 11 unfixed fibulae at a different level to the tibia fracture healed with good alignment but the among the 20 fibulae at the same level of tibia fracture that were left unfixed , 12 cases ended up in malalignment. An overall union rate of 96% was reported but evidences do suggest that some fibular fixations improve alignment and union of tibial fractures. [23]

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Vallier et al have reported higher rates of malalignment with nailing rather than plating without any difference in the final outcome function wise. [24]

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4.AIM OF THE STUDY

To find the differences in correcting the valgus angle in distal tibia and fibula fractures with or without fibular plating in the distal one-third leg , before nailing of the tibial fracture.

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5.MATERIALS AND METHODS

Period of study – between August 2014 and August 2016 , both bone leg fractures in the distal one third level , who presented to our casualty were included in this study.

5.1. IMPLANTS USED

UNIVERSAL TIBIA NAIL

SSEPL universal tibia nail made of stainless steel was used in all of these patients. They are available in a range of lengths from 28cm till 38cm and diameter from 7mm till 10 mm. Each nail has a proximal bevelled tip to prevent soft tissue irritation. There was a 11 degree proximal bend (Herzog's bend) in its upper end to facilitate proper insertion of the nail due to the anterior entry point and provide a good fit. There are two transverse proximal interlocking slots – one for dynamic bolt and other static bolt and three distal interlocking slots – two transverse and one antero-posterior options. The distal tip of the nail has been tapered to avoid peneterating the posterior cortex and to facilitate easier sliding of the nail in the medullary canal.

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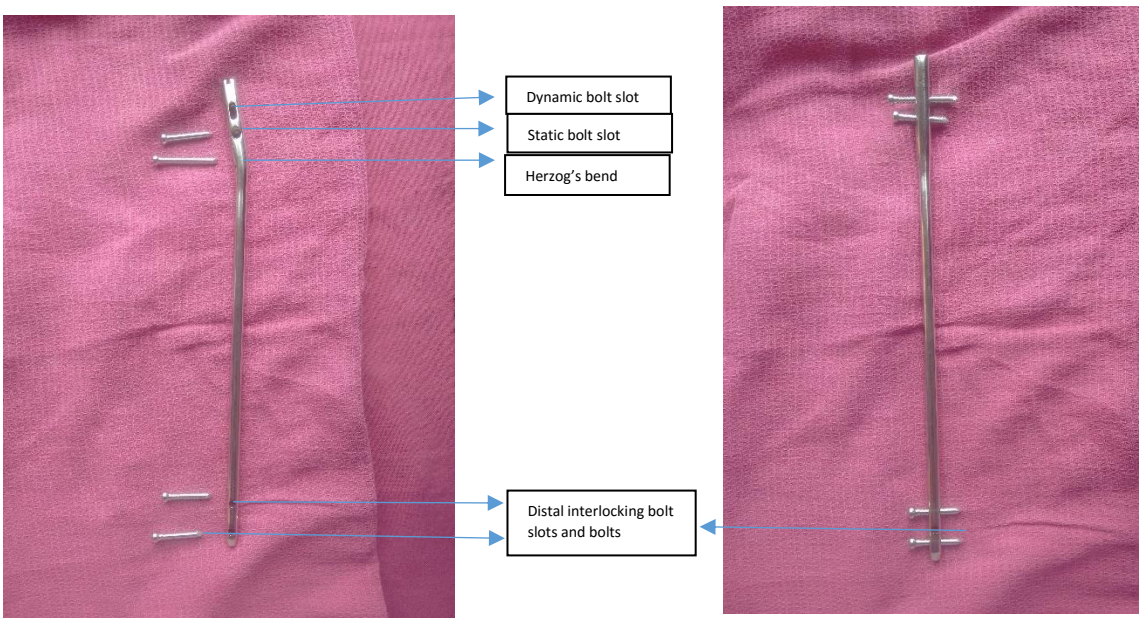

Figure 5.1- Intramedullary nail – Anteroposterior and lateral views

Fibular plate

A SSEPL stainless steel 1/3rd tubular plate, with 3.5mm screw system was used. The lengths varied from 6 holes till 10 holes to accommodate 3.5mm cortical and cancellous non-locking screws.

Figure 5.2 – 1/3rd Tubular plate and 3.5mm screws

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5.2INCLUSION CRITERIA

1)Closed fractures distal one-third tibia and fibula with fracture

2)Grade I (Gustillo-Anderson classification) fractures distal one-third tibia and fibula with fracture

3)Fracture pattern-Transverse, oblique ,spiral and wedge comminuted fractures

4)Fractures mentioned above with severe initial valgus deformity and unacceptable reduction after plaster application

5) Age – adults from 20 to 60 years of age

6) Decision on inclusion of patients in the group fibular plating was done depending on the consent of the patient for fibular plating

5.3 EXCLUSION CRITERIA

1)Fractures in upper and middle one-third tibia and fibula

2)Grade II and Grade III (Gustillo-Anderson) compound fractures

3)Fracture pattern-severely multifragmented fractures

4) Age less than 20 and more than 60 years

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5.4 ASSESSMENT OF PARAMETERS

1)Pre-operative – Blood haemoglobin , Blood sugar , urea, creatinine , ECG , Chest X-ray and X-rays of the involved region. . The preoperative measurement of tibia nail length and width were made . (tibial tuberosity to ankle joint line measurement minus 1cm ,taken as a guide for the length and width measured at the narrowest part of the medullary canal in the lateral radiograph)

5.5 SURGICAL TECHNIQUE

GROUP 1

After obtaining informed written consent from the patients , the affected limb and the back were prepared, ie., for both the spinal anaesthesia and the operative procedure of the affected limb. Administration of pre-operative prophylactic antibiotics was done. After induction of spinal anaesthesia , a pneumatic tourniquet was applied at the level of upper middle thigh . Pre operative preparation of the affected limb with 7.5% betadine solution , from mid thigh till the toes was done. Sterile draping of the patient was done. The intraoperative blood pressure was recorded ,the limb was exsanguinated and the tourniquet was inflated 120mm of Hg above the patient's systolic blood pressure. The degree of flexion of the knee could be controlled intraoperatively using a remote control of the operating table . Incision was made over the midline , midway between the tibial tuberosity and the inferior pole of the patella over the patellar tendon. The patellar tendon was split tibial plateau was visualised. Entry

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point was made midway between the tibial articular surface and the tibial tuberosity with bone awl with knee in flexion so as to avoid penetration of the posterior cortex.Further reaming of the proximal fragment opening into its medullary canal was done using a 6mm diameter rigid intramedullary nail reamer. Guide wire was then passed across the fracture site into the distal fragment , after the reduction of the fracture under fluoroscopy guidance. After confirming the guide wire position, progressive reaming of the medullary canal was done with an intramedullary reamer , of 0.5mm increments till the “chatter” is heard and no more further reaming was possible. A nail size of 0.5 mm less than the maximal reaming size was chosen and the length of the nail was again verified with the preoperative measurement. The nail was assembled on to the jig (external guide) and passed through the entry point and progressed across the fracture site till 1cm proximal to the ankle joint line as seen in the C-arm. Care was taken to ensure that there was no rotational deformities , by aligning the tip of the second toe in line with the upper pole of the ipsilateral patella. The two 5mm distal interlocking bolts were placed under imaging guidance after measuring the depth of the same. Two 5mm proximal interlocking bolts were then placed and the nail was locked stably in its position. Patellar tendon was repaired including the paratenon layer using 1’0 Vicryl® , subcutaneous sutures placed using 1’0 Vicryl® and skin was sutured along with the stab wounds made for the placement of the interlocking bolts. Tourniquet was deflated before wound closure to ensure perfect hemostasis. Sterile dressing was then applied .

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STEP	CLINICAL IMAGE
INCISION	
REDUCTION AND PASSING OF GUIDE WIRE	
PROGRESSIVE REAMING OF MEDULLARY CANAL	
INTRODUCTION OF NAIL	
PROXIMAL AND DISTAL LOCKING	

Table 5.1- Surgical Steps – Tibia nailing- Group I and II

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GROUP 2

This group first had an open reduction and internal fixation of fibula fracture, then followed by closed nailing of the tibial fracture. To facilitate change of position after fibular plating in midway of surgery suitable adjustment of the operating table could be done. The patient is placed with a sandbag under the ipsilateral buttock to enable better visualisation of the ipsilateral fibula area with knee in extension. The limb was prepared and draped from mid-thigh to the toes , after application tourniquet at upper middle thigh level and leg was placed extended on the table. By a posterolateral incision between the soleus and the peronei muscles the fibular fracture was exposed reduced and fixed with a 1/3rd tubular plate. The length of the plate depended upon the pattern of the fracture. The plate was either applied as a simple compression plate, bridge plate or a neutralisation plate . The wound was closed. By adjusting the remote control, the knee was then flexed and tibia nailing is done as described for Group 1 patients. Wounds were closed after tourniquet release and achieving haemostasis.

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STEP	CLINICAL IMAGE
INCISION FOR FIBULAR PLATING	
REDUCTION AND PASSING OF 1/3RD TUBULAR PLATE	
FIXATION WITH SCREWS	
AFTER FIXATION OF FIBULA	

Table 5.2 – Surgical Steps – Fibular plating- Group II

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5.6 POST OP CARE

In both groups patients were given prophylactic antibiotics . Patients were given Inj.Cefotaxime® 1g 6 hours after and 12 hours after . All patients were given Inj.Low Molecular Weight Heparin 40 milligram subcutaneously once daily for the first 5 days post operatively. All patients were given soft padded elastocrepe bandage for leg and foot segment to enable mobilisation. Adequate pain relief was provided to these patients to enable mobilisation. No blood was transfused to any of our patients. All patients had CPM (Continuous Passive Mobilisation) from the 2nd post operative day till the 12th post operative day. Then the patients were discharged after suture removal

Post-operative radiodiagnosis – Full leg radiographs were taken and the degree of valgus in distal 1/3rd tibia were measured. The same compared with pre-operative radiographs of the same patient. The percentage of the correction was noted. The same was tabulated and was compared for statistical significance as to whether prior fibular plating was really useful in correcting the valgus of the distal fragment.

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5.7 DISCUSSION OF CASES DONE

GROUP I- INTRAMEDULLARY NAILING WITHOUT FIBULAR PLATING

In this group a total of 13 cases were operated with intramedullary nailing for tibia without fibular plating. They were treated as in patients till the 12th post operative day and then discharged. All these cases came for regular follow up but for 4 patients who did not adhere to the follow up instructions. Few of these cases are illustrated here.

ILLUSTRATIVE CASES

CASE 1

Ms.KTK , 28 year old male , suffered an injury to his left leg due to road traffic accident causing injury to his presented with swelling and deformity in the lower part of left leg , with a small puncture wound of 1cm x 1cm over the anterior aspect. There was no distal neurovascular deficit. He was immobilised in a Thomas splint, administered analgesics and investigations done. His radiographs showed a distal 1/3rd fracture of tibia and fibula with lateral and anterior displacement. A calcaneal pin traction was applied and patient put on a Bohler-Braun Splint. After routine investigations and after obtaining anaesthetic fitness , the patient was explained about the nature of surgery and due written consent was obtained.

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Figure 5.3- Pre-operative radiographs – AP and lateral

He was taken up for surgery 11 days after injury .A Closed reduction and internal fixation of tibia was done using a midline incision over patellar tendon, entry point made over proximal tibial slope and guide wire passed after reduction. Progressive reaming of the medullary canal done from 6mm till 10mm , in 0.5mm increments and IMILN (34cm X 9mm) passed and locked with 4 Nos 5mm interlocking bolts (2 proximal and 2 distal). Intra operative blood loss was about 75 ml for this patient.

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Figure 5.4 – Immediate post-operative radiograph

His post-operative period was uneventful. No blood transfusions were given to him. The Wound dressings changed on 2nd , 5th , 8th post-operative days and suture removal done on the 12th day. His wounds healed well .

This patient was mobilised from the second post-operative day. Quadriceps strengthening exercises and active range of movement exercises were started for the knee and ankle joint .

Patient was followed up at 4th, 8th, and 14th weeks with standard antero posterior and lateral radiographs.

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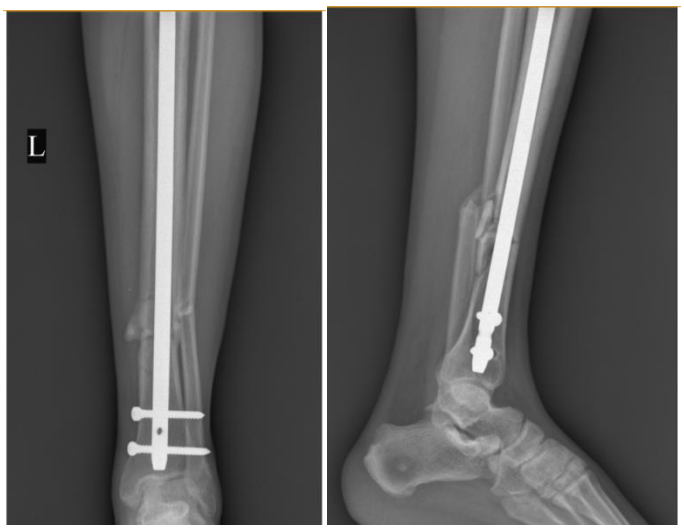

Figure 5.5 – 8 weeks post operative radiograph

Patient was initially advised non- weight bearing ambulation and at 6 weeks gradually progressed to partial weight bearing ambulation.

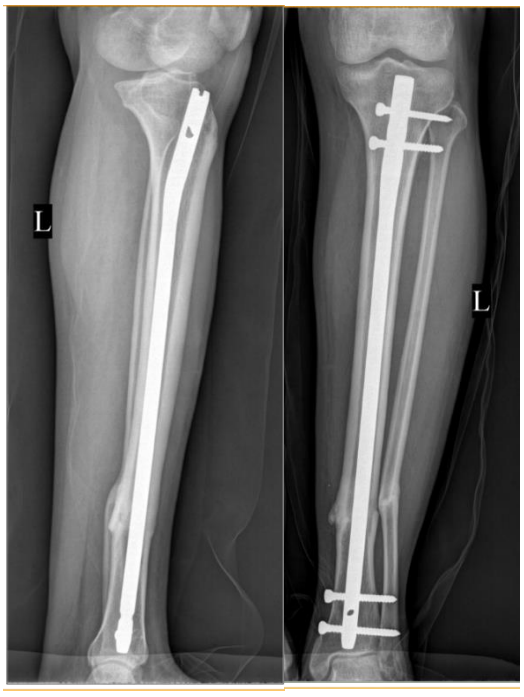

Figure 5.6 – 12 weeks post-operative radiograph

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Patient had an uneventful solid union of both tibia and fibula at the end of 14 weeks . The valgus angulation of the distal fragment was measured to be preoperatively 1.8^0 with lateral displacement and 4.34^0 post operatively. There were no deformities in the sagittal plane.

Figure 5.7 – Final valgus angulation (4.34^0)

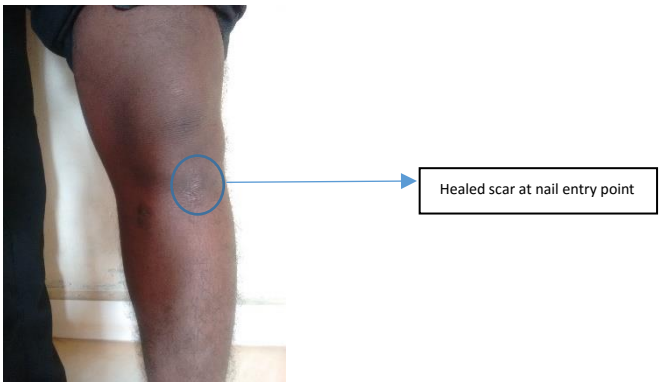

Figure 5.8 – Post-operative clinical image

Patient had full range if movements of both knee and ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to his normal daily activities.

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CASE 2

Mr. AKS , 30 year old male , fell accidentally at his work place from a height of about 5 feet resulting causing injury. He brought to us in an ambulance with swelling and deformity in the lower part of left leg. After confirming that there was no neurovascular deficit, he was immobilised in Thomas splint , administered adequate analgesia and investigations were ordered. His radiographs showed a distal 1/3rd fracture of tibia and fibula with medial and anterior displacement. A calcaneal pin traction was applied and patient put on a Bohler-Braun Splint. After routine investigations and after obtaining anaesthetic fitness , the patient was explained about the nature of surgery and due written consent was obtained.

Figure 5.9 - Preoperative radiograph

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He was taken up for surgery 14 days after injury . Closed reduction and internal fixation of tibia done after progressive reaming of the medullary canal, with an intramedullary interlocking nail (34cm X 10mm) passed and locked with 4 5mm interlocking bolts (2 proximal and 2 distal). Intra operative blood loss was about 75 ml.

Figure 5.10 – Immediate post-op radiograph

His post-operative period was uneventful. No blood transfusions were given to him. Regular wound dressing done on 2nd , 5th , 8th post-operative days and suture removal done on the 12th day. His wounds healed normally.

Patient was mobilised on the 2nd Post-operative day with quadriceps strengthening exercises and active range of movement exercises for the knee and ankle joint .

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Patient was followed up at 4, 6 and 12 weeks with standard antero posterior and lateral radiographs.

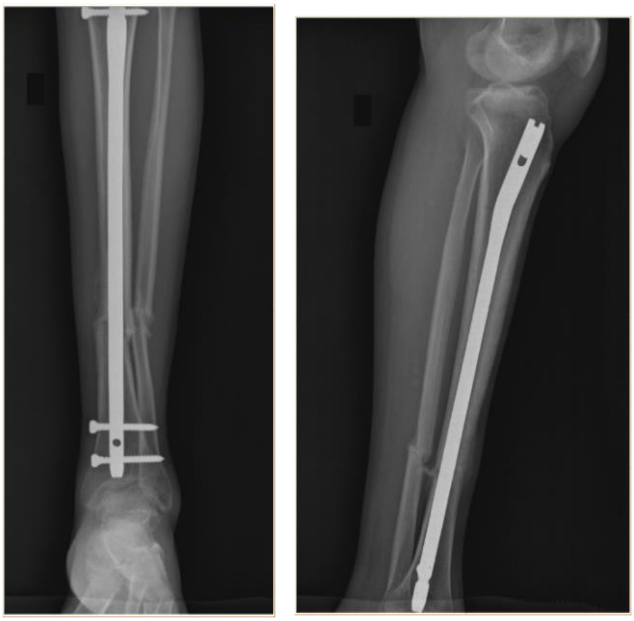

Figure 5.11- Six weeks post-op radiograph of 2nd patient

Figure 5.12 – 12 weeks post-op radiograph of 2nd patient

Patient had an uneventful solid union of both tibia and fibula at the end of 12 weeks . The valgus angulation of the distal fragment was determined to be

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preoperatively 5.25^0 which decreased to 3.55^0 post operatively. There were no deformities in the sagittal plane.

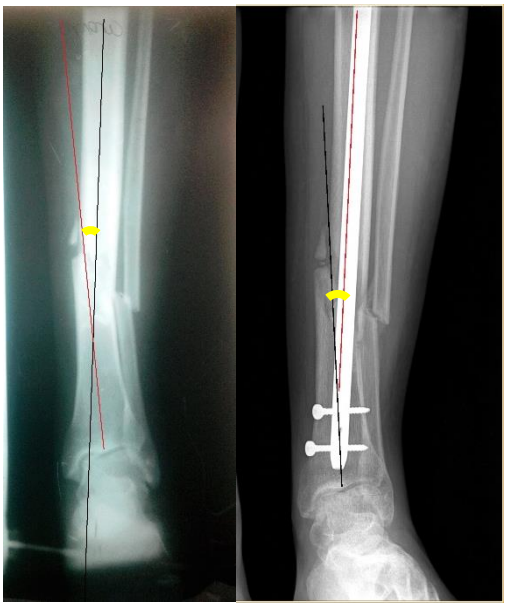

Figure 5.13 – Pre-operative (5.25^0) and post-operative (3.55^0) valgus

Patient had full range if movements of both knee (flexion 110^0, no extensor lag) and ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to his normal daily activities.

`

CASE 3

Mr.GVN , 60 year old male , a known asthmatic, suffered an injury to his right leg due to vehicular accident. He presented to our trauma casualty with swelling and deformity in the lower part of right leg . We ensured he had no neurovascular deficit and his right leg was immobilised in a Thomas splint. He was given adequate pain relief and investigations done. The right leg radiographs obtained showed fractures of tibia and fibula in the distal 1/3rd of the leg. He was immobilised in an above knee slab . He was under intravenous bronchodilators and regular nebulisations with Salbutamol and budesonide. After routine investigations and after obtaining anaesthetic fitness , the patient was explained about the nature of surgery and due written high risk consent was needed as the patient was suffering from chronic obstructive pulmonary disease.

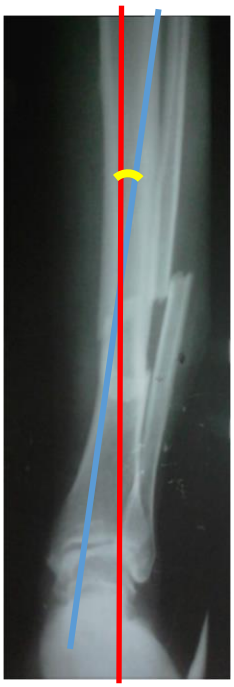

Figure 5.14- Pre-operative radiograph (valgus – 8.47^{0})

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He was taken up for surgery 21 days after injury due to delay in assessment . Closed reduction and internal fixation of tibia done using a midline incision over patellar tendon, entry point made over proximal tibial slope and guide wire passed after reduction. Progressive reaming of the medullary canal done in 0.5 increments till 10mm and an intramedullary nail (32cm X 9mm) passed and locked with three 5mm interlocking bolts (1 proximal and 2 distal). The intra operative blood loss was about 75 ml.

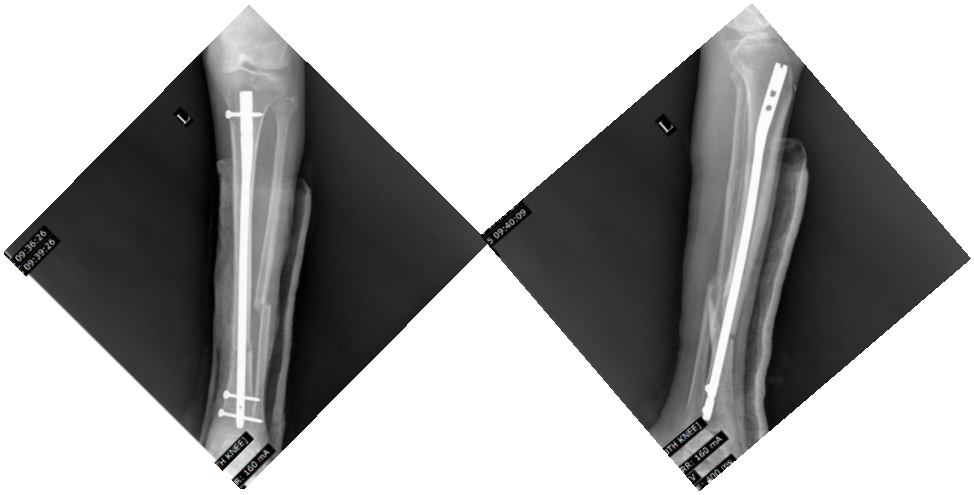

Figure 5.15 – Immediate post-operative radiograph

His immediate post-operative period was uneventful. No blood transfusions were given to him. Regular wound dressing done on 2nd, 5th, 8th post-operative days and suture removal done on the 12th day. His wounds healed normally.

Patient was mobilised on the 2nd post-operative day. Quadriceps strengthening exercises and active range of movement exercises for the knee and ankle joint.

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Patient was followed up at 4, 6, and 12 weeks with standard Antero posterior and lateral radiographs.

Figure 5.16 – 4 week post-operative radiograph

Figure 5.17 – 12 week post-operative radiograph

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Figure 5.18 –Post-operative valgus – 4.14^0

At the end of 4 weeks this patient developed swelling and sero-purulent discharge at the proximal dynamic interlocking bolt site. The infection settled after 2 weeks of specific antibiotics. The patient also had a pressure sore over the posterior aspect of the heel , due to immobilisation in a slab. Serial collagen granule dressing was applied and the wound settled after 6 weeks. Patient progressed to solid union of both tibia and fibula by 14 weeks. The valgus angulation of the distal fragment was 8.47^0 pre – operatively and was 4.14^0 post operatively. There were no deformities in the sagittal plane.

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Patient had full range if movements of both knee (flexion 110 ^{0} , no extensor lag) and ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to his normal daily activities .

A procedure for implant removal was done after solid clinical and radiographic union , as the patient had sero-purulent discharge on and off from the proximal interlocking bolt site It was 19 months post operatively that the implant exit was done.

Figure 5.19 – Radiograph after implant exit

`

GROUP II – TIBIA NAILING WITH FIBULAR PLATING

In this group a total of 12 patients were operated with open reduction and fixation of the distal 1/3rd fibula fracture with an 1/3rd tubular plate followed by closed intramedullary interlocking nailing for tibia. All of these patients were followed up till the end and 3 of them were irregular in their follow up visits. Few of these cases are illustrated here.

ILLUSTRATIVE CASES

CASE 1

Mr.SHM , 23 year old male , met with a road traffic accident , while riding a bike skid and fell. This resulted in injury to his right lower leg . He was already immobilised in an above knee slab at the time of presentation after first aid at a nearby Government Hospital. On opening the plaster to inspect for any wounds , swelling and deformity was present in the lower part of right leg. He was administered adequate analgesia. Investigations after a radiological diagnosis of distal 1/3rd fracture of tibia and fibula were made. It was observed that there was no coronal plane deformity but there was minimal overriding.

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AP LAT

Figure 5.20- Pre-operative radiographs

Immobilisation done with Above knee slab . Anaesthetic fitness was obtained and patient was explained about the nature of surgery and due written consent was obtained.

Patient was taken up for surgery 14 days since injury . First via a posterolateral approach , appropriate dissection , fibular fracture was exposed , the long oblique fracture was reduced and fixed with fibular plating done using 8 holed 1/3rd tubular plate and 6 cortical screws (3 proximal and 3 distal) followed by closed reduction and internal fixation of tibia done using a midline incision over patellar tendon, lateral entry point made over proximal tibial slope , guide wire passed

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after reduction , progressive reaming and passage of intramedullary interlocking nail of tibia (30cm X 9mm) locked with four 5mm interlocking bolts (2 proximal and 2 distal). Intra operative blood loss in this patient was less than 150 ml.

Patient was stable in the immediate post operative period . No blood transfusions were given . Regular wound dressing done on 2^{nd} , 5^{th} , 8^{th} post operative days and suture removal done on the 12^{th} day. The wounds healed normally .

Patient was mobilised on the 2^{nd} post operative day , quadriceps strengthening exersies and active range of movement exercises for the knee and ankle joint .

Immediate post operative radiographs revealed acceptable reduction and alignment .

AP Lateral

Figure 5.21 – Immediate post-operative radiograph

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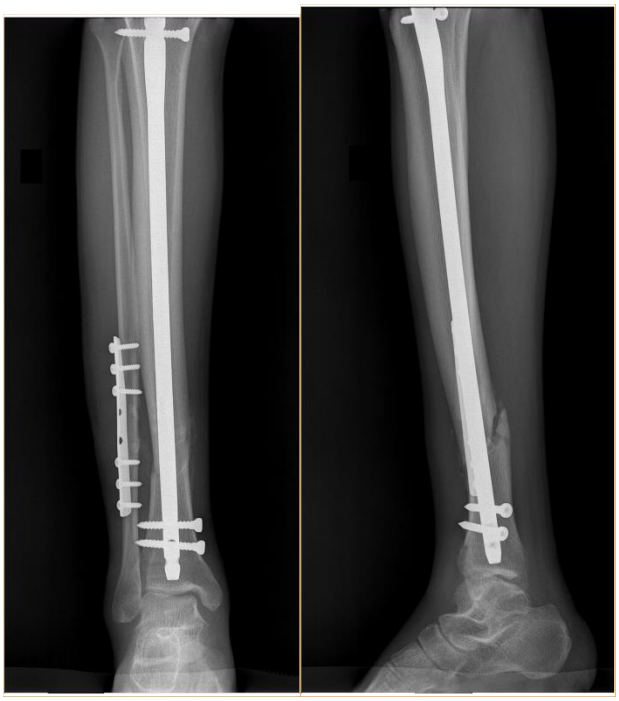
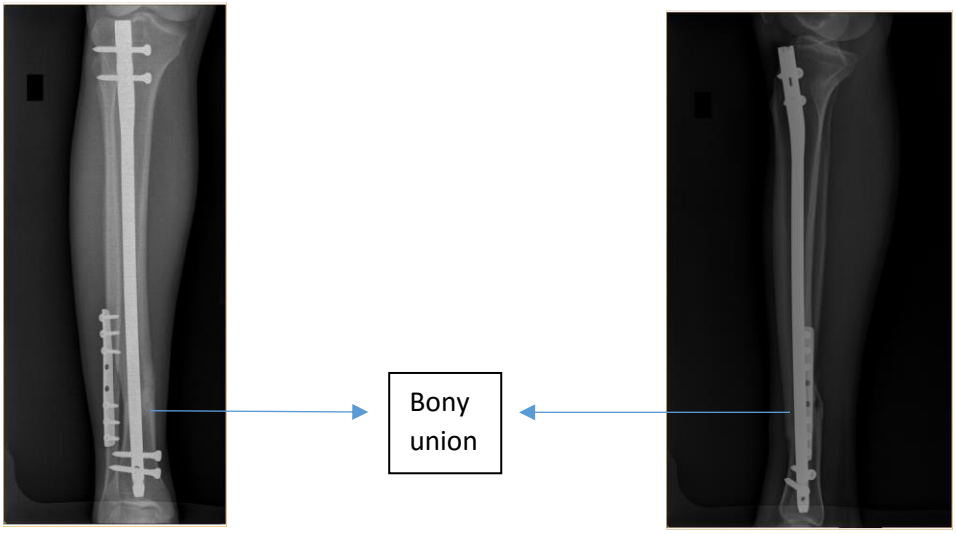
Patient was followed up at 4 , 6 , and 12 weeks with standard antero posterior and lateral radiographs.



AP Lateral

Figure 5.22 – 6 weeks post-operative X-ray



AP Lateral

Figure 5.23 - 12 weeks post-operative X-ray

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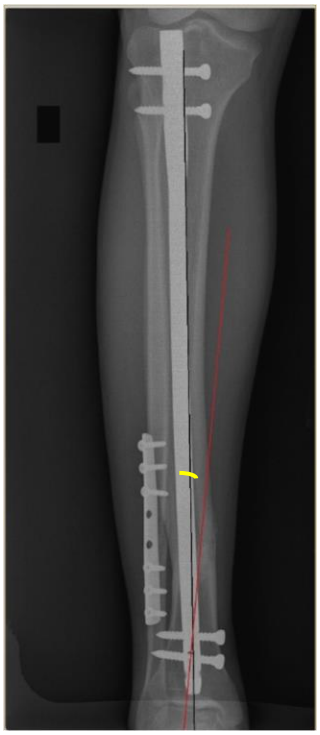

Figure 5.24 – Post union valgus angle

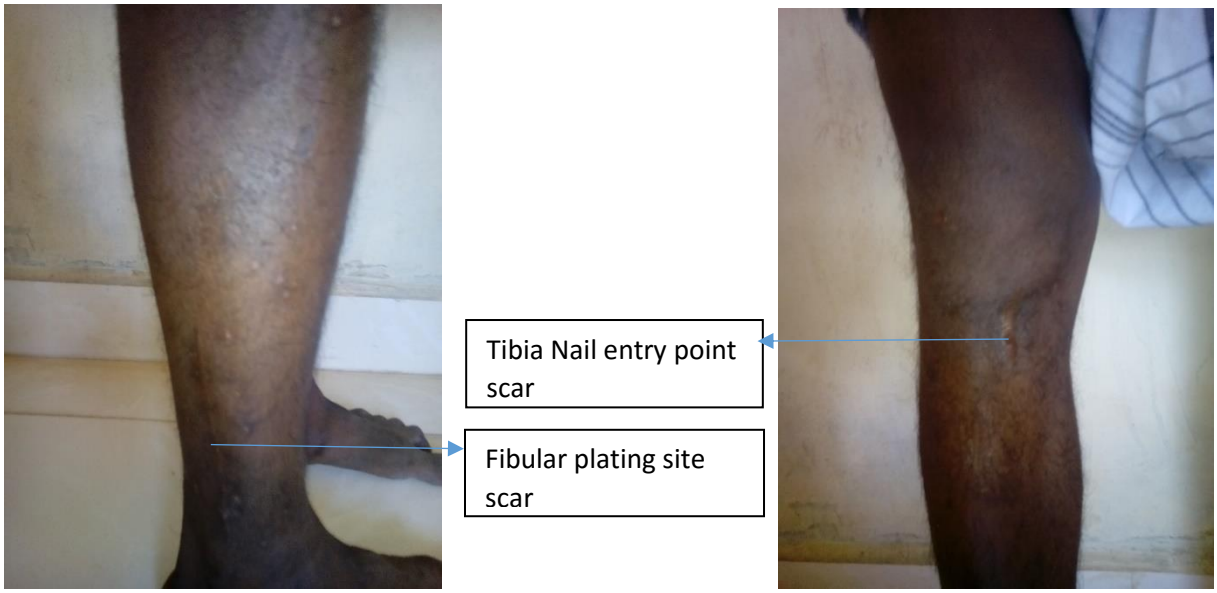

Figure 5.25 , 5.26 – Post operative clinical images

`

Patient had a solid union of both tibia and fibula at the end of 12 weeks . The valgus angulation of the distal fragment was 5.76 ^{0} post operatively. There were no deformities in the sagittal plane .

Patient had full range if movements of both knee (flexion 120 ^{0}s , no extensor lag) and ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to his normal daily activities .

Post operatively there were no complications like infection , delayed union , non union or compartment syndrome.

`

CASE 2

Mr.ASK , 31 year old male came to us with a closed injury to his left leg due to an accident while riding a two wheeler , when he lost balance a and fell with the bike on his left lower limb. He complained of swelling and deformity in the lower left leg . There was no distal neurovascular deficit. He was immobilised in Thomas splint , administered analgesics and investigations obtained. His radiographs showed distal 1/3rd fracture of tibia and fibula ,with valgus angulation . Immobilisation with an above knee slab was done . He was taken up for surgery after routine investigations. Anaesthetic fitness was obtained and the patient was explained about the nature of surgery and due written consent was obtained.

AP LAT

Figure 5.27 - Preoperative radiographs

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Patient was taken up for surgery 10 days after injury .Under tourniquet control ,first by a posterolateral approach , appropriate dissection , fibular fracture was exposed , the transverse fracture was reduced and fixed with fibular plating , using 6 holed 1/3rd tubular plate and 6 cortical screws (3 proximal and 3 distal) followed by closed reduction and internal fixation of tibia done using a midline incision over patellar tendon entry point made over proximal tibial slope and guide wire passed after reduction. Progressive reaming of the medullary canal done and intramedullary interlocking nailing (34cm X 10mm) passed and locked with 4 5mm interlocking bolts (2 proximal and 2 distal). Intra operative blood loss was less than 100 ml for this patient.

Patient was stable in the immediate post op period . No blood transfusions were given . Regular wound dressing done on 2nd , 5th , 8th post operative days and suture removal done on the 12th day. His wounds healed normally .

Patient was mobilised on the 2nd post operative day , quadriceps strengthening exercises and active Range of Movement exercises for the knee and ankle joint .

Immediate post operative radiographs for this patient revealed acceptable reduction and alignment . This patient was followed up at 4 , 6 , and 12 weeks after surgery with standard antero posterior and lateral radiographs.

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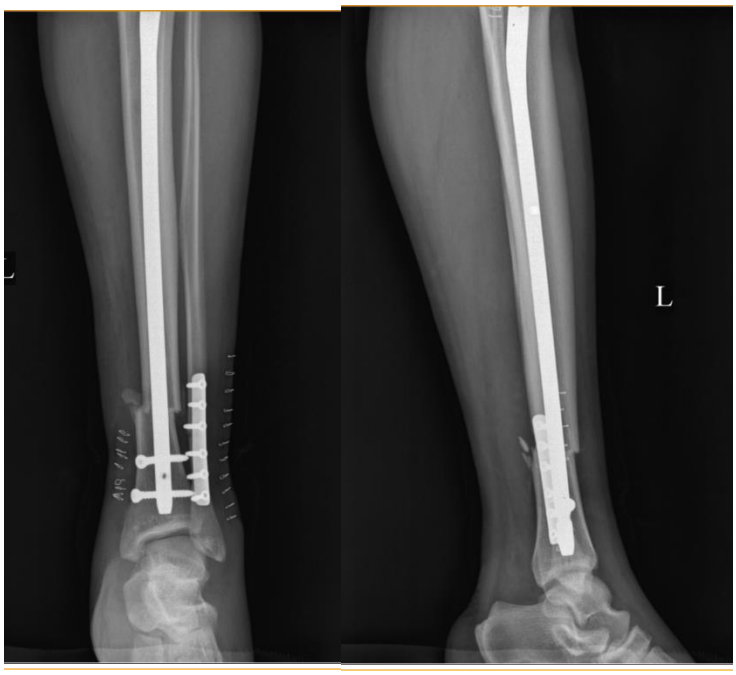

AP LAT

Figure 5.28 – Immmediate post operative radiographs

AP LAT

Figure -5.29 -- 4 weeks post operative radiographs

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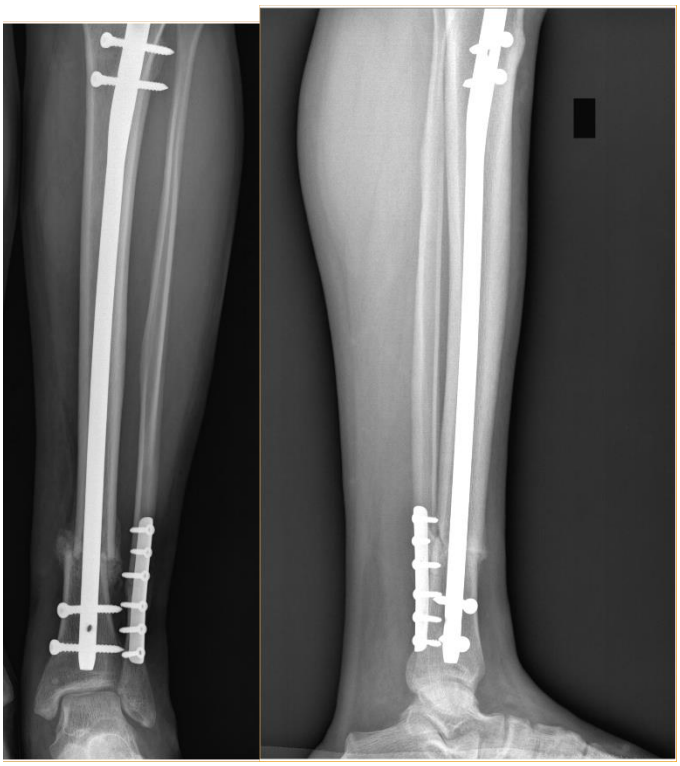
Patient had solid union of both tibia and fibula at the end of 12 weeks . The valgus angulation of the distal fragment changed from 13.21 ^{0} pre operatively to 4.31 ^{0} post operatively. There were no deformities in the sagittal plane..



AP LAT

Figure 5.30 – 10 weeks post operative radiograph

Patient had full range if movements of both knee (flexion 110 ^{0} , no extensor lag) and ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to her normal daily activities . There were no post operative complications.

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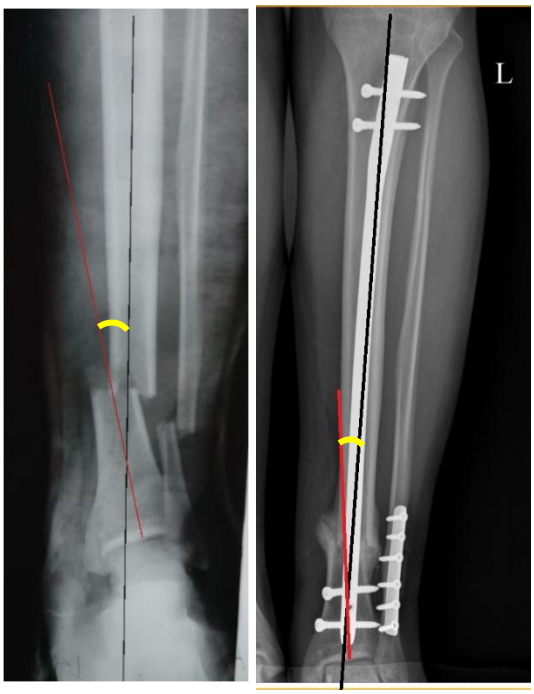

AP LAT

Figure 5.31 Pre operative(13.21 ^{0}) and Post operative valgus (4.31 ^{0}) angles

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CASE 3

Mr.NRN , 45 year old male , suffered an injury to his left leg due to accidental fall causing a closed injury to left leg. He presented to us with swelling and deformity in the lower part of his left leg. His distal pulses were normal. He was quickly immobilised in a Thomas splint. He was given adequate analgesics and investigations obtained. His radiographs showed distal 1/3rd fracture of tibia and fibula ,with 2cm overriding and lateral displacement of the distal fragment . Immobilisation done with an above knee slab and prepared for surgery. After routine investigations, an anaesthetic fitness was obtained and patient was explained about the nature of surgery and due written consent was obtained.

AP LAT

Figure 5.32 - Preoperative radiographs

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Patient was taken up for surgery 1 week after injury . A pneumatic tourniquet was applied and by a posterolateral approach , appropriate dissection , fibular fracture was exposed , the multifragmented fibular fracture was reduced using reduction forceps and fixed with an 8 holed 1/3rd tubular plate and 6 cortical screws (3 proximal and 3 distal). By this , in the C-arm the tibial fracture was seen to be reduced. This was followed by internal fixation of tibia done using a midline incision over patellar tendon, entry point made over proximal tibial slope and guide wire passed after reduction.Progressive reaming of the medullary canal done and intramedullary interlocking nailing (32cm X 10mm) passed and locked with 4 5mm interlocking bolts (2 proximal and 2 distal). Intra operative blood loss for this patient was about 200 ml.

Immediate post operative C-arm images showed acceptable reduction and alignment after fibular plating.

Figure 5.33– C-arm image after fibular plating

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Figure 5.34 – Immediate post operative radiographs

Patient was stable in the immediate post operative period . No blood transfusions were given for this patient. Regular wound dressing done on 2nd , 5th , 8th post operative days and suture removal done on the 12th day. The operative wounds healed normally .

Patient was mobilised from the 2nd post operative day , quadriceps strengthening exercises and active range of movement exercises for the knee and ankle joint were started.

Immediate post operative radiographs revealed acceptable reduction and alignment .

`

Patient was followed up at 4 , 6 , and 12 weeks with standard antero posterior and lateral radiographs.

Figure 5.35- 4 weeks post operative radiograph

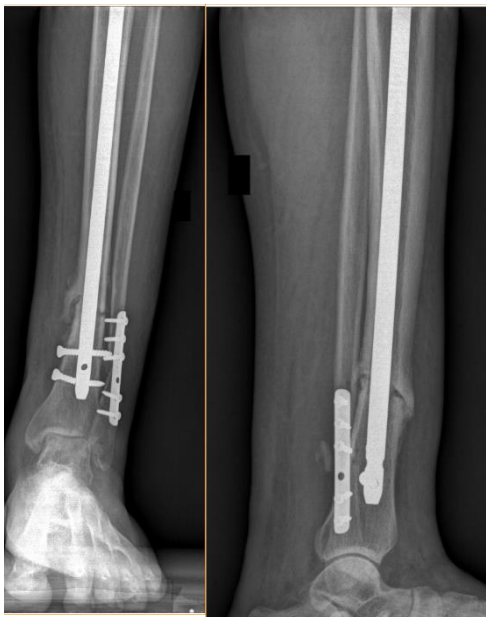

Figure 5.36 – 15 weeks post operative radiographs

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Patient's union was delayed and as the patient started bearing weight in the operated limb the distal most interlocking bolt broke , thus dynamising the nail . At about 18 weeks ,patient went for a solid union . The valgus angulation of the distal fragment was 8.86^0 preoperatively and 2.71^0 post operatively. It is to be noted that in spite of the dynamisation there was no increase in valgus angle. There were no deformities in the sagittal plane.

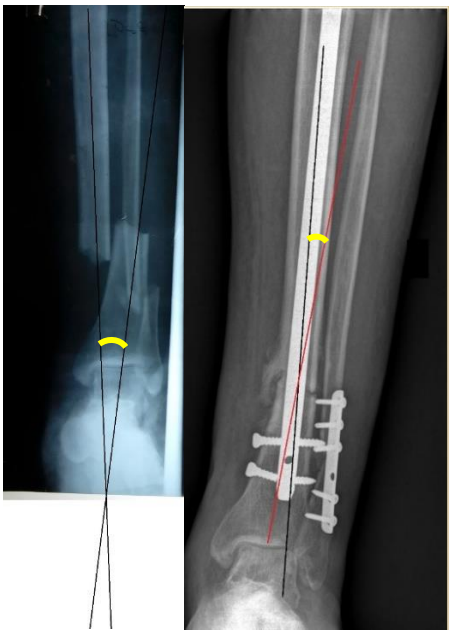

Figure 5.37 – Pre-operative (8.86^0) and Post-operative valgus (2.71^0)

Patient had full range of movements of the knee. His flexion was 120^0. There was no extensor lag and full range of movements at the ankle at the end of union and had no difficulty in full weight bearing ambulation and returned to his normal daily activities . Patient was a manual labourer by occupation and was gradually eased into occupational activity.

`

Problems in this case :

Intraoperatively in this case the comminuted fibula fracture posed difficulty in maintaining length of the fragment, as there was overriding of the distal fragment.

Post – operatively , there was an increased distance of the nail from the distal articular surface and it caused self dynamisation of the nail when the patient started weight bearing.

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6. RESULTS

In this prospective case control study, a total 25 cases were studied , treated with intramedullary interlocking nailing for tibia with or without fibular plating. All these cases were studied in the period between August 2014 and August 2016.

A summary of the cases has been provided in the table 5.1. The complete details of all the cases has been given in the Master Chart.

S.no	**Parameter**	**GROUP I**	**GROUP II**
1	Total number of cases	13	12
2	Males	11	10
3	Females	2	2
4	Solid union	11	11
5	Infection	3	1
6	Repeat procedure	1	2
7	Anterior knee pain	5	4
8	Correction <5 degree	10	8
9	Average time for union	15	14.72
10	Self dynamisation	0	1
11	Average difference in pre and post operative valgus	4.0067	6.34

Table 5.1 – Summary of cases

`

In the first group , operated with only tibia nailing were 13 cases in total (11 males and 2 females) and the total patients in Group II were 12 (10 males and 2 females). Average age of the patients in Group I was 37.92 years and group II was 41.67 years . The total duration of study was 24 months. Patients were followed up till radiological and clinical union of the fracture.

We noted male preponderance in our study(83% males in Group I and 85% males in Group II). The predominant mode of injury was road traffic accident.

All patients had immediate post-operative radiographs taken and the resulting valgus / varus angles were measured and recorded. Patients were advised continuous follow up regularly at 4 , 8 and 12 weeks . 4 patients among group I and 3 patients from group had erratic follow up visits. In group I, the average time to union was 15 weeks compared to group II which was 14.27 weeks. The mean pre-operative valgus angle in the two groups were 8.37° and 11.37° respectively ($p = 0.09 > 0.05$). The mean valgus angle post operatively was 4.36° and 4.96° respectively ($p = 0.24 > 0.05$). The average difference between pre and post-operative valgus angle was 4.0067 and 6.34 in the two groups. Percentage of correction achieved in group I was 47.8% and group II was 55.7%.

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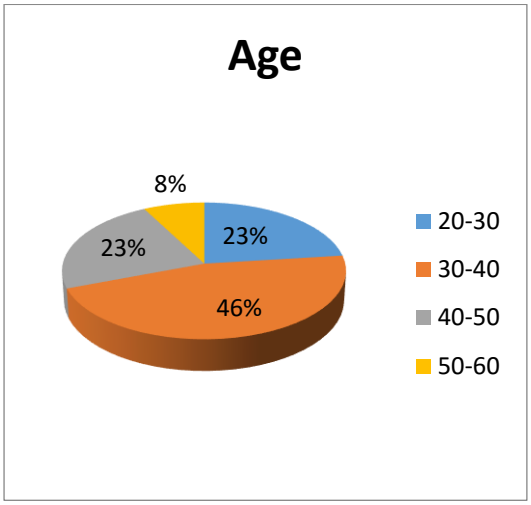
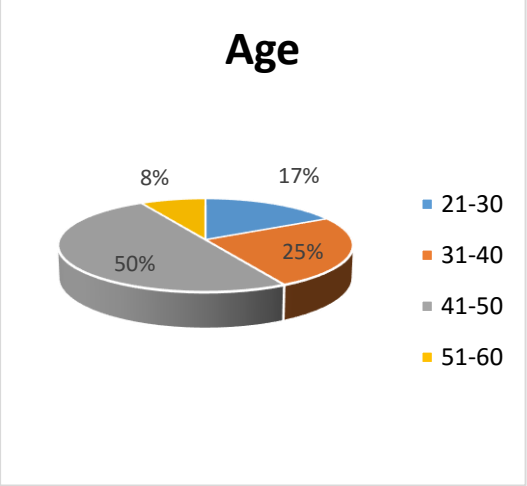
AGE DISTRIBUTION

GROUP I



GROUP II



GENDER

GROUP I

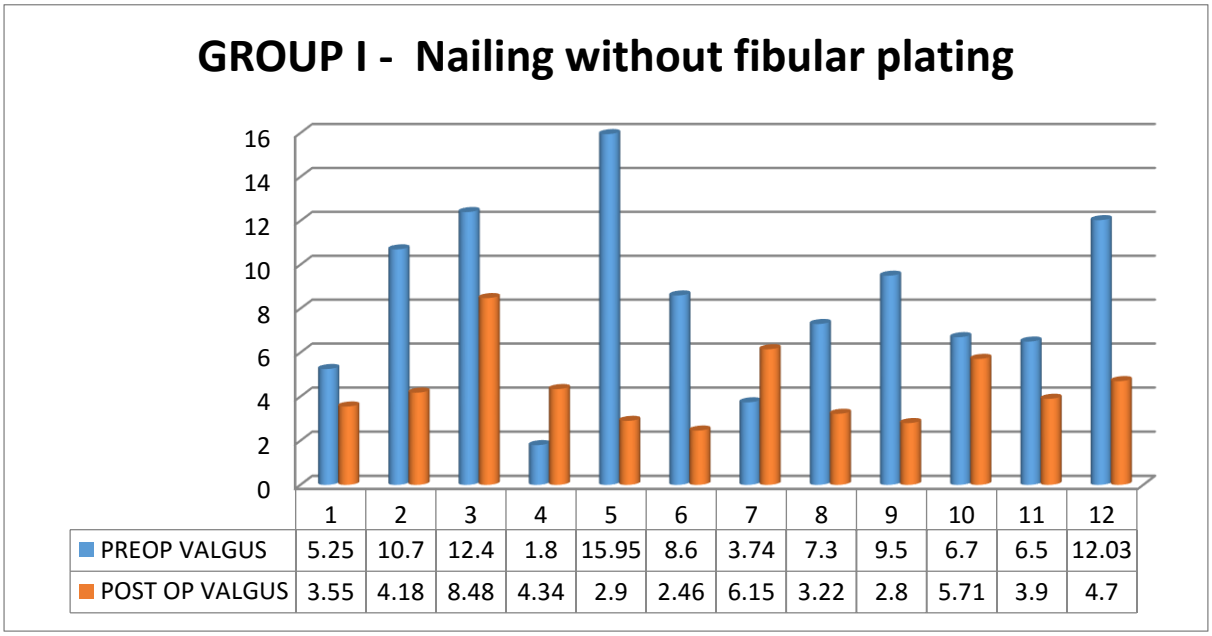
Gender	No. of Cases	%
Male	11	85%
Female	2	15%

GROUP II

Gender	Nos.	%
MALE	10	83%
FEMALE	2	17%

PRE-OPERATIVE AND POST OPERATIVE VALGUS ANGLES

GROUP I



	1	2	3	4	5	6	7	8	9	10	11	12
PREOP VALGUS	5.25	10.7	12.4	1.8	15.95	8.6	3.74	7.3	9.5	6.7	6.5	12.03
POST OP VALGUS	3.55	4.18	8.48	4.34	2.9	2.46	6.15	3.22	2.8	5.71	3.9	4.7

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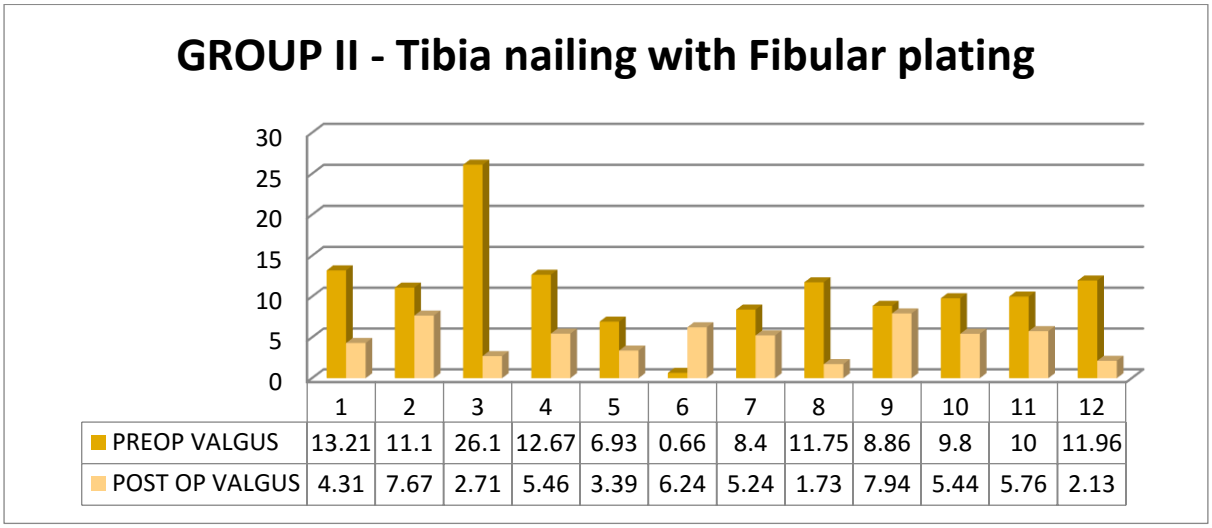
GROUP II



LENGTH OF THE NAIL

GROUP I

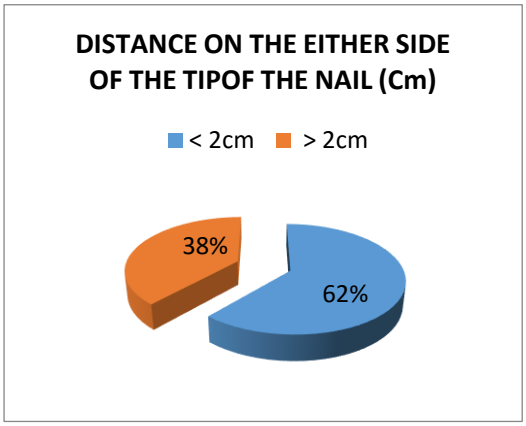
LENGTH OF THE NAIL (Cm)	f	%
28-30	2	15 %
30-32	4	31 %
32-34	6	46 %
34-36	1	8 %

GROUP II

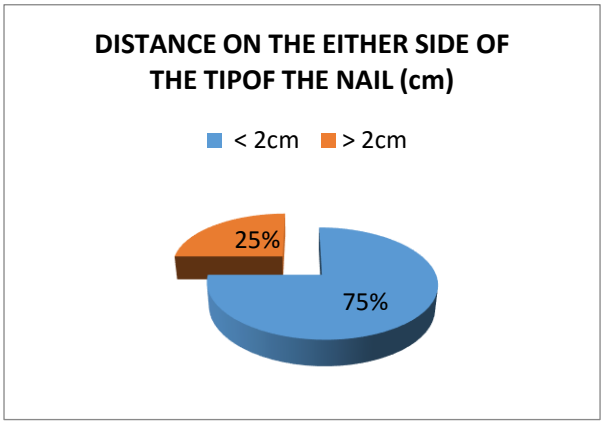
LENGTH OF THE NAIL (Cm)	F	%
24-28	2	17%
28-32	4	33%
32-36	6	50%

DISTANCE ON EITHER SIDE OF TIP OF THE NAIL

GROUP I



GROUP II



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DIAMETER OF THE NAIL

GROUP I

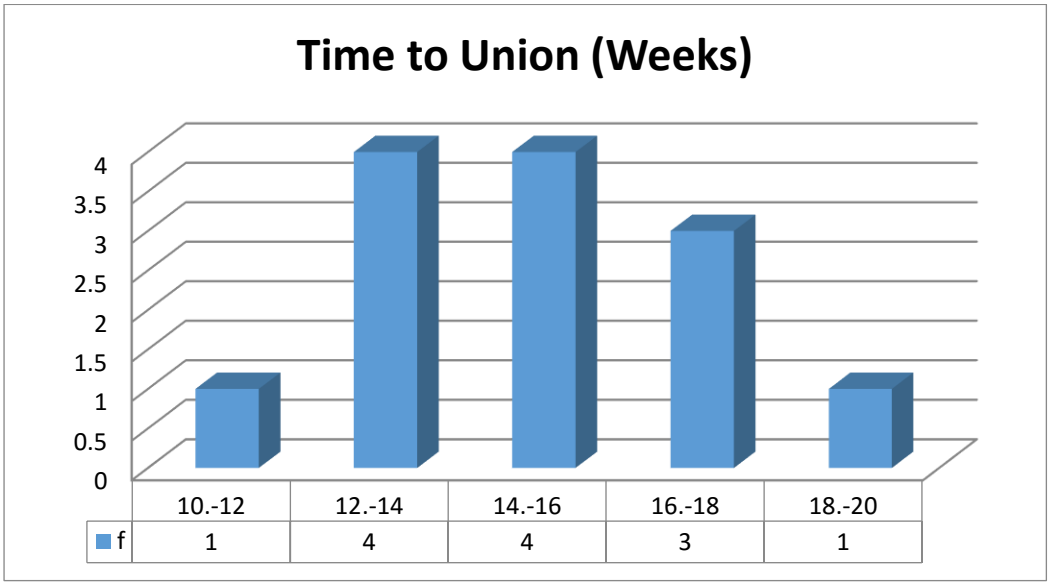
DIAMETER OF THE NAIL	f	%
</= 9mm	4	38 %
> 9mm	9	62 %

GROUP II

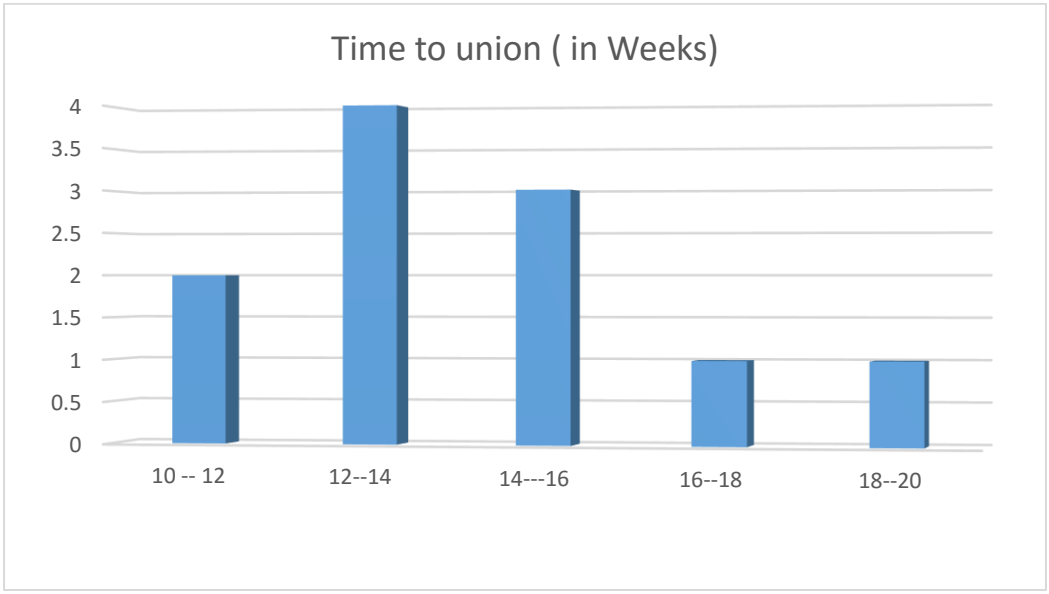
DIAMETER OF THE NAIL	F	%
</=9mm	2	17%
> 9mm	10	83%

TIME TO UNION

GROUP I



GROUP II



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There were no incidences of fibular non-union or infection in any of the cases of group II.

One patient in each group had varus angulation at the end of union , within acceptable limits.

With respect to complications the commonly reported issues were anterior knee pain ,infection, delayed union and non union . Anterior knee pain was reported in 5 patients (38.14%) in group I and 4 patients (30%) in group II. 3 patients (23.1%) in group I had complaints of sero-purulent discharge and fever post operatively. One patient had infection at proximal dynamic bolt site ,, 1 at the distal bolt site and 1 at the fracture site. The latter two patients settled with intravenous antibiotic administration and wound dressing. The first patient needed an implant exit after union of the fracture, 19 weeks after the day of surgery. Patient was then put on protective patellar tendon cast for weight bearing, One patient (8.3%) among the group II had infection at both the tibial fracture site and proximal interlocking bolt sites. Patient was given intravenous antibiotics and regular wound dressing for the wounds at both the sites. Patient proceeded to union and nail removal was done at the end of 19 months.

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2 patients from each of the groups had delayed union (Group I – 15.39%, Group II- 16.67%). One patient (8.3%) from the group II had frank non union with no signs of radiological union in 4 and 8 week follow up x-rays. No cases were reported with frank non union in group I.

One patient in group II had delayed union and as the patient had started bearing weight the distal most interlocking bolt broke and nail went for self dynamisation. The fracture united uneventfully by 18 weeks.

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7. DISCUSSION

In our study we intended to evaluate the difference in the outcome of treatment of distal third tibia and fibula fractures in the presence and absence prior fibular fixation to tibial intramedullary interlocking nailing, as a case control study. This particular entity has been controversial and several studies published in this regard have given controversial results. Our aim was to throw more light on the issue of the benefit the fibular plating provides, with main focus on the resulting valgus deformity correction in these fractures. The demographic data in both groups were very comparable.

While several studies exist to support fibular fixation prior to tibia fixation in case of intraarticular fractures of the distal tibia, the resources supporting extra articular fractures are limited.

A study by ***Egol et al*** , offered support to fibular plating in concomitant tibia and fibula fractures in the distal third of leg , by stating that the fixation of fibula before tibia nailing served to reduce the incidence of loss of alignment. They also claimed that the fibular fixation was useful in maintanence of reduction beyond 12 weeks post operatively. They recommended fibular plating in distal third fractures when an intramedullary nailing is considered.[11] In support with this , our study there was minimal loss of alignment of the distal third fractures in whom fibular plating was done. It is also to be noted that there was no significant difference in the valgus angulation in the immediate pre op and follow up radiographs.

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In our study we observed intra operatively that the fibular plating done before tibia nailing offered the advantages of maintaining the length of the limb , assisting in the indirect reduction of tibia and maintenance of the same till intramedullary nailing is completed. Additionally this aids in minimising the difficulty in manipulation during the reduction and fixation of tibia fracture , which aids in lesser soft tissue damage and better healing as a result. A similar observation was made by studies conducted by ***R Buzzi et al***[25] and ***Ajay Krishnan et al*** [3] .

The rotational stability offered by fixation of fibula was evident in our cases , due to which, when tibial nailing was done the construct was stable enough . This fact has been supported by results of studies by ***Bonnevialle et al*** [6] , which stated though the definitive role of fibula fixation could not be implicated in case scenarios , biomechanical studies did support its importance. The significance of fibular plating offering rotatory stability has also been reported by ***Kumar et al***[7] and ***Morin PM et al.*** [8]

Strauss et al [9] have also showed fibular fixation when done efficiently is useful in a better fixation when used along with an interlocking nail , who otherwise have advocated the use of locking plates for distal leg fractures.

Evidences that advocate no use or detrimental use of fibular plating are also available and have to considered before drawing a conclusion. ***Rouhania et al*** [5] , have concluded that the fibula plating neither any advantage in tibial fixation and maintenance of alignment nor did it lead to any unwanted

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complications like infection and non union**.** ***Varsalona et al***[29] , have bluntly disqualified the use of concurrent fibular fixation stating that only an external fixator or in this case a tibia nail is sufficient enough for stability and maintenance of reduction in distal third leg fractures.

Mustafa et al [2] , have distinctly stated that a properly done intramedullary nailing for tibia alone with a minimum of two distal interlocking bolts is sufficient enough for maintenance of reduction and alignment even when adjunctive stabilisation like poller screws and fibular plating are not used. This was proved to be right with respect to our study by the fact that the post operative valgus angulation in the group that did not receive fibular plating , was within the acceptable limits of malalignment.

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8 .SUMMARY OF THE STUDY

25 cases were prospectively studied for post-operative valgus angulation, when treated with interlocking nailing alone or interlocking nailing with fibular plating. Though the individual post-operative valgus angle measurements for the group without fibular plating is lesser than the group which received fibular plating , the percentage of correction of valgus achieved post-operatively from pre-operative level was more significant in the latter group. This study indicates that fibular fixation does offer an improved outcome when compared to tibia nailing done without it and does not lead to any increased incidences of complications.

`

ANNEXURES

ANNEXURE – 1

PROFORMA

1. Name:

2. Age:

3. Sex:

4. Occupation:

5. Address:

6. I.P No:

7. Presenting H/o: Side: L/R

   Swelling Yes / No

   Deformity Yes / No

   Associated injuries Yes /No

8. History and type of trauma: RTA/ACCIDENTAL FALL

   others / Sports).

9. Duration between injury and surgery:

10. Associated medical problems:

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11. Clinical Examination Finding:

    Tenderness –

    Crepitus-

    Deformity-

    Abnormal mobility-

    External Wounds-

    Associated injuries -

12. Investigation X-Ray , Blood investigation reports:

13. Type of anaesthesia – General / Spinal:

14. Surgery done – Tibia nailing with Fibular plating / without fibular plating

15. Implant details -

16. Suture removal done on --post-op day

17. Mobilisation of knee and ankle started on -

18. Assessment:

    - 1st pod

    - 4th week

    - 8th week

    - 12th week

`

19. Complications:

- Injury site infection yes / no
- Surgical site infection yes / no
- Non union yes / no
- Fever yes / no
- Anterior knee pain yes / no

`

CONSENT AND INFORMATION SHEET

1. We are conducting a prospective study on **"COMPARISON OF RESULTS OF INTERLOCKING NAILING OF TIBIA WITH OR WITHOUT FIBULAR PLATING IN DISTAL ONE-THIRD BOTH BONE FRACTURES ."**
2. At the time of announcing the results and suggestions, name and identity of the patients will be confidential
3. Taking part in this study is voluntary. You are free to decide whether to participate in this study or withdraw at any time, your decision will not result in any loss of benefits to which you are otherwise entitled.
4. The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment

Signature of the Investigator **Signature of the Patient/Guardian**

Date

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ஆராய்ச்சி தகவல் தாள்

தஞ்சை அரசு மருத்துவக் கல்லூரியில் கெண்டைக்காலின் இரண்டு எலும்புகளும் முறிந்து வரும் நோயாளிகளுக்கு அறுவை சிகிச்சை செய்வது தொடர்பாக ஒரு ஆராய்ச்சி நடைபெற்று வருகிறது.

இதில் தாங்களும் பங்கேற்று பயன் பெற விரும்புகிறோம். இந்த ஆராய்ச்சியில் காலில் அறுவை சிகிச்சையின் பொழுது ஒரு சிலருக்கு பெரிய எலும்புக்கு உள்ளே கம்பி மட்டும் பொருத்தியும் மற்றும் சிலருக்கு கம்பியுடன் சிறு எலும்புக்கு வெளியே தட்டு ஒன்று கூடுதலாக பொருத்தியும் சிகிச்சை செய்யவிருக்கிறோம் . இரண்டுமே நல்ல சிகிச்சையாக இருப்பினும் எதனால் எலும்பு முறிவு அதிகமாக சீராக வாய்ப்புள்ளது என்பதை அறியும் விதமாக இந்த ஆராய்ச்சி தொடங்கப்பட்டு உள்ளது .

முடிவுகளை அல்லது கருத்துக்களை வெளியிடும் போதோ அல்லது ஆராய்ச்சியின் போதோ தங்களது பெயரையோ அடையாளங்களையோ வெளியிட மாட்டோம் என்பதையும் தெரிவித்து கொள்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களின் விருப்பத்தின் பேரில் தான் இருக்கிறது. மேலும் நீங்கள் எந்நேரமும் இந்த ஆராய்ச்சியில்லிருந்து வெளியேறலாம் என்பதையும் தெரிவித்து கொள்கிறோம்.

இந்த பரிசோதனையின் முடிவுகளை ஆராய்ச்சியின் போது அல்லது ஆராய்ச்சியின் முடிவின் போது தங்களுக்கு அறிவிப்போம் என்பதை தெரிவித்துகொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் பங்கேற்பாளர்
கையொப்பம்

தேதி :

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MASTER CHART

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GROUP I - Nailing without fibular plating											
S.No	NAME	AGE/SEX	DATE OF INJURY	LEVEL OF INJURY	PREOP VALGUS	POST OP VALGUS	IMPLANT USED	LENGTH OF THE NAIL	DIAMETER OF THE NAIL	DISTANCE ON THE EITHER SIDE OF THE TIPOF THE NAIL	TIME TO UNION
1	GVN	60/M	7TH AUG ,2014	8cm proximal to Ankle joint	10.7	4.18	Tibia IMILN	32cm	9mm	3 cm	19 weeks
2	ARK	30/M	28th DEC, 2014	9 cm proximal to Ankle joint	5.25	3.55	Tibia IMILN	34cm	10mm	2.4cm	12 weeks
3	SRD	36/M	20th MAR , 2015	8cm proximal to Ankle joint	6.5	3.9	Tibia IMILN	32cm	10mm	1.8cm	16 weeks
4	KSL	45/F	2nd JULY , 2015	9cm proximal to Ankle joint	9.5	2.8	Tibia IMILN	28cm	9mm	1.9 cm	17 weeks
5	SKT	31/M	7th AUG , 2015	8cm proximal to Ankle joint	7.3	3.22	Tibia IMILN	36cm	10mm	2.26cm	16 weeks
6	JKY	32/M	29TH , SEP, 2015	10cm proximal to Ankle joint	12.4	8.48	Tibia IMILN	34cm	10mm	2.6cmn	17 weeks
7	KRT	28/M	14TH OCT,2015	8cm proximal to Ankle joint	1.8	4.34	Tibia IMILN	34cm	9mm	2 cm	14 weeks

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8	KNN	45/M	19th OCT,2015	10cm proximal to Ankle joint	6.7	5.71	Tibia IMILN	34cm	10mm	2.25cm	18 weeks
9	SRN	40/M	20th OCT , 2015	11cm proximal to Ankle joint	3.74	6.15	Tibia IMILN	32cm	10mm	1.46cm	14 weeks

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GROUP II - Tibia nailing with Fibular plating														
S.No	NAME	AGE/SEX	DATE OF INJURY	LEVEL OF INJURY	PREOP VALGUS	POST OP VALGUS	IMPLANT USED	LENGTH OF THE NAIL	DIAMETER OF THE NAIL	DISTANCE ON THE EITHER SIDE OF THE TIPOF THE NAIL	PLATE USED	LENGTH OF THE PLATE	NO. OF SCREWS USED	TIME TO UNIO N
1	STK	43/M	20th AUG, 2014	9 cm proximal to ankle	11.96	2.13	Tibia IMILN	34cm	10cm	2.17cm	1/3rd Tubular Plate with 3.5mm cortical screws	6 holed	6 screws	14 weeks
2	MRM	43/M	3rd JAN ,2015	10 cm proximal to ankle	12.67	5.46	Tibia IMILN	32cm	10mm	1.9cm	1/3rd Tubular Plate with 3.5mm cortical screws	6 holed	6 screws	19 weeks
3	KRT	28/F	3rd FEB, 2015	8 cm proximal to ankle	26.1	2.71	Tibia IMILN	28cm	9mm	1.7cm	1/3rd Tubular Plate with 3.5mm cortical screws	8 holed	6 screws	12 weeks
4	SHM	23/M	5TH FEB , 2015	10 cm proximal to ankle	10	5.76	Tibia IMILN	30cm	9mm	1.74cm	1/3rd Tubular Plate with 3.5mm cortical screws	8 holed	6 screws	12 weeks

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5	ASK	35/M	3rd MAR 2015	8 cm proximal to ankle	13.21	4.31	Tibia IMILN	34cm	10mm	1.98cm	1/3rd Tubular Plate with 3.5mm cortical screws	6 holed	6	14 weeks
6	MRD	45/M	6th JUN,2015	11 cm proximal to ankle	(-)6.93	(-)3.39	Tibia IMILN	34cm	10mm	2.29cm	1/3rd Tubular Plate with 3.5mm cortical screws	7 holed	7 screws	15 weeks
7	MRG	40/M	14th JULY , 2015	10 cm proximal to ankle	11.75	1.73	Tibia IMILN	34cm	10mm	1.83cm	1/3rd Tubular Plate with 3.5mm cortical screws	7 holed	6 screws	13 weeks
8	RJD	46/M	18TH JULY , 2015	10 cm proximal to ankle	9.8	5.44	Tibia IMILN	34CM	10MM	1.74cm	1/3rd Tubular Plate with 3.5mm cortical screws	7 holed	6 SCREWS	15 weeks
9	MGM	55/M	6th SEP, 2015	11 cm proximal to ankle	8.4	5.24	Tibia IMILN	34cm	10mm	2.3cm	1/3rd Tubular Plate with 3.5mm cortical screws	7 holed	6 screws	16 weeks
10	MTZ	60/F	1st NOV, 2015	10 cm proximal to ankle	0.66	6.24	Tibia IMILN	28cm	10mm	1.23cm	1/3rd Tubular Plate with 3.5mm	7 holed	7 screws	14 weeks

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											cortical screws			
11	NRN	42/M	13th NOV , 2015	9 cm proximal to ankle	8.86	7.94	Tibia IMILN	32CM	10MM	1.46cm	1/3rd Tubular Plate with 3.5mm cortical screws	6 HOLED	5 screws	18 weeks
12	KLSV	40/M	24th MAY, 2016	10 cm proximal to ankle	11.1	7.67	Tibia IMILN	32cm	10mm	1.8cm	1/3rd Tubular Plate with 3.5mm cortical screws	7Holed	6 screws	non union

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